MICROSCAN

DMx Verifier+™ User Manual

V2.1.0, Feb 2009

EM-20136-1V210

Copyright and Disclaimer
Copyright ©2009 by Microscan Systems, Inc.
1201 S.W. 7th Street, Renton, WA, U.S.A. 98057
(425) 226-5700 FAX: (425) 226-8682

All rights reserved. The information contained herein is proprietary and is provided solely for the purpose of allowing customers to operate and/or service Microscan manufactured equipment and is not to be released, reproduced, or used for any other purpose without written permission of Microscan.

Throughout this manual, trademarked names might be used. Rather than place a trademark (™) symbol at every occurrence of a trademarked name, we state herein that we are using the names only in an editorial fashion, and to the benefit of the trademark owner, with no intention of infringement.

Disclaimer
The information and specifications described in this manual are subject to change without notice.

Latest Manual Version
For the latest version of this manual, see the Download Center on our web site at: www.microscan.com.

Technical Support
For technical support, email: helpdesk@microscan.com.

Microscan Systems, Inc.
1201 S.W. 7th Street
Renton, WA 98057
U.S.A.
Tel: 425 226 5700
Fax: 425 226 8250
helpdesk@microscan.com

Microscan Europe
Tel: 31 172 423360
Fax: 31 172 423366

Microscan Asia Pacific
R.O. Tel: 65 6846 1214
Fax: 65 6846 4641

Microscan Limited Warranty Statement and Exclusions

What Is Covered?
Microscan Systems Inc. warrants to the original purchaser that products manufactured by it will be free from defects in material and workmanship under normal use and service for a period of one year from the date of shipment. This warranty is specifically limited to, at Microscan's sole option, repair or replacement with a functionally equivalent unit and return without charge for service or return freight.

What Is Excluded?
This limited warranty specifically excludes the following: (1) Any products or parts that have been subject to misuse, neglect, accident, unauthorized repair, improper installation, or abnormal conditions or operations; (2) Any products or parts that have been transferred by the original purchaser; (3) Customer mis-adjustment of settings contrary to the procedure described in the Microscan Systems Inc. owners manual; (4) Upgrading software versions at customer request unless required to meet specifications in effect at the time of purchase; (5) Units returned and found to have no failure will be excluded; (6) Claims for damage in transit are to be directed to the freight carrier upon receipt. Any use of the product is at purchaser's own risk. This limited warranty is the only warranty provided by Microscan Systems Inc. regarding the product. Except for the limited warranty above, the product is provided "as is." To the maximum extent

permitted by law, this express warranty excludes all other warranties, express or implied, including but not limited to, implied warranties of merchantability and. Technical support questions may be directed to: helpdesk@microscan.com Register your product with Microscan: www.microscan.com/register fitness for a particular purpose. Microscan Systems Inc. does not warrant that the functions contained in the product will meet any requirements or needs purchaser may have, or that the product will operate error free, or in an uninterrupted fashion, or that any defects or errors in the product will be corrected, or that the product is compatible with any particular machinery.

Limitation of Liability

In no event shall Microscan Systems Inc. be liable to you or any third party for any special, incidental, or consequential damages (including, without limitation, indirect, special, punitive, or exemplary damages for loss of business, loss of profits, business interruption, or loss of business information), whether in contract, tort, or otherwise, even if Microscan Systems Inc. has been advised of the possibility of such damages. Microscan Systems Inc.'s aggregate liability with respect to its obligations under this warranty or otherwise with respect to the product and documentation or otherwise shall not exceed the amount paid by you for the product and documentation. Some jurisdictions do not allow the exclusion or limitation of incidental or consequential damages or limitations on an implied warranty, so the above limitation or exclusion may not apply to you. This warranty gives you specific legal rights, and you may also have other rights which may vary from state to state.

Tel: 425.226.5700 | Fax: 425.226.8250 | helpdesk@microscan.com

Contents

PREFACE **Welcome! xi**

Purpose of This Manual **xi**
Manual Conventions **xi**

CHAPTER 1 Before You Begin... **1-1**

DMx Verifier+ **1-1**
- Base Configuration 1-2
- System Configuration 1-2

Scanning Options **1-3**
PC Requirements **1-3**
Software Installation **1-4**
Installing Hardware **1-4**
- Basic Setup Procedures 1-4
- General Location Considerations 1-4
- Environmental Requirements 1-5
- Recommended Tools 1-5
- Installing the 0300 Board 1-5
- Installing the Internal Camera Power Cable 1-6
- Connecting the Camera Cable 1-6
- Camera Mount 1-7
  - Checklist 1-7
  - Ensuring the Best Field of View 1-8
  - Adjusting the Camera Position 1-9

Clamping the Lens 1-9
Rebooting the System & Starting DMx Verifier+ 1-10
You Are Done **1-12**

CHAPTER 2 DMx Verifier+ Overview **2-1**

Introduction **2-1**
Description of Measured Parameters **2-3**
AIM Verification (ISO 16022) 2-3
Symbol Contrast (SC) 2-3
Axial Nonuniformity (AN) 2-4
Print Growth (PG) 2-4
Unused Error Correction (UEC) 2-4
Overall Symbol Grade 2-5
IAQG Verification (AS9132, Rev A) 2-5
Dot Size 2-6
Dot Center Offset 2-6
Angle of Distortion 2-7
Ovality 2-7
Module Fill 2-7
Symbol Contrast 2-7
Overall Grade 2-7
ISO 15415 Verification 2-7
Reference Decode 2-8
Symbol Contrast (SC) 2-8
Axial Nonuniformity (AN) 2-8
Grid Nonuniformity (GN) 2-9
Unused Error Correction (UEC) 2-9
Fixed Pattern Damage 2-10
Modulation 2-10
Print Growth 2-10
Scan Grade 2-10
Overall Grade 2-10
DPM Verification 2-10
Center Offset (CO) 2-11
Size Offset (SO) 2-11
Cell Modulation (CM) 2-12
Border Match (BM) 2-12
Symbol Contrast (SC) 2-13
Axial Nonuniformity (AN) 2-13
Print Growth (PG) 2-14

Unused Error Correction (UEC) 2-14
Angle of Distortion (AD) 2-15
Overall Grade 2-15
Verification Status **2-15**
Verification Guidelines and Examples **2-16**
System Setup 2-16
Parameter Considerations 2-16
General Parameters 2-16
IAQG/AS9132 Parameters 2-17
ISO 15415 Parameters 2-18
DPM Parameters 2-18
Examples of Data Matrix Verification 2-19
IAQG 2-19
DPM 2-27

CHAPTER 3 DMx Verifier+ Operations **3-1**

Verifier Operations **3-1**
Auto Check 3-1
Sample 1 — Perfect Data Matrix Image 3-3
Sample 2 — Data Matrix with Errors 3-6
Sample 3 — Overprinted Data Matrix 3-11
Sample 4 — Underprinted Data Matrix 3-13
Auto Check in List Mode 3-14
Verification Results Reporting **3-16**
Printing the Verification Results Only 3-16
Printing the Data to a File 3-17
Printing the Image with Verification Results 3-17
Printing the Image Only 3-17

CHAPTER 4 DMx Verifier+ Reference Guide **4-1**

Verifier Menu Descriptions **4-1**
File Menu 4-2
File>Open 4-2
File>Open List 4-2
File>MXi 4-3
File>Grab 4-3
File>Live 4-3
File>Save As 4-4

File>Print 4-4
File>Job 4-4
File>Exit 4-4
Set Menu 4-5
Set>ROI 4-5
Set>Center Offset 4-6
Set>Size Offset 4-6
Set>Error Correction 4-7
Set>Grading Base 4-8
Set>Log Header 4-10
Set>Log Data Delimiter 4-11
Set>Log String 4-11
Set>Log Data 4-11
Set>Internal Sync 4-11
Set>Hardware Trigger 4-11
Set>MXi Upload 4-12
Set>MXi Compression 4-13
Set>MXi Auto Mode 4-13
View Menu 4-15
View>DMx Property 4-15
View>DMx Data 4-15
View>Threshold Display 4-16
View>Contrast Display 4-16
View>Zoom In 4-16
View>Undo Zoom 4-16
View>Solid Grid 4-16
View>Lite Grid 4-16
View>Camera 4-16
View>MXi String 4-16
View>MXi ID Form 4-17
View>MXi Header 4-17
Pre Process Menu 4-18
Pre Process>Undo 4-18
Pre Process>Erode 4-18
Pre Process>Dilate 4-18
Pre Process>Open 4-18
Pre Process>Close 4-18
Tools Menu 4-19
Tools>Auto Check 4-19
Tools>Contrast/Size Calibration 4-19
Tools>Target ROI 4-22

Tools>Encode Data Matrix 4-25
Help Menu 4-27
Help>License Key 4-27
Help>About 4-27

APPENDIX A Data Matrix Symbology **A-1**

Data Matrix Certification **A-1**
What Is Data Matrix? **A-1**
Data Matrix Components **A-3**
Bit Versus Code Word A-4
Data Matrix Error Correction **A-5**
Data Matrix Encodation Schemes **A-6**
ECC 000-140 A-6
ECC 200 A-7
Data Matrix Specification Details **A-9**
Summary of Additional Features **A-10**
Symbol Structure **A-11**

APPENDIX B Creating A Good Image **B-1**

Introduction **B-1**
Determining the Field Of View **B-2**
Selecting Lens **B-2**
Using the Lens Selection Chart B-3
Illuminating the Part **B-4**
Lighting Considerations B-5
Types of Lighting B-5
Fluorescent Versus Incandescent Lighting B-6
Lasers B-7
Strobe Lights B-7
Diffuse Versus Point-Source Lighting B-7
Placement of Light Sources B-9
Front Lighting B-9
Side Lighting (Dark Field) B-9
Back Lighting B-10
Polarized Light B-10

Advanced Lighting **B-11**
DOAL B-12
CDI B-13
SCDI B-14
Aperture **B-15**
Depth Of Field **B-16**
Lighting Tips **B-16**

Index **Index-1**

PREFACE

Welcome!

Purpose of This Manual

This manual is a comprehensive guide to set up, install, and use the DMx Verifier+ software and related hardware. It also includes information on Data Matrix symbology and image acquisition.

Manual Conventions

The following typographical conventions are used throughout this manual.

- Items emphasizing important information is **bolded**.
- Menu selections, menu items and entries in screen images are indicated as: Run (triggered), Modify..., etc.

CHAPTER 1 Before You Begin...

Before you install your DMx Verifier+ system, ensure that you have all the necessary components. This chapter presents the steps to help you prepare for and perform a successful hardware and software installation.

DMx Verifier+

The DMx Verifier+ is a complete 2D Direct Part Mark (DPM) quality verification system for the Data Matrix™ symbology. It is designed to work on all types of direct part marking and label marking applications. It is compliant with major public standards for Data Matrix quality verification, such as the original AIM Uniform Symbology Specification for Data Matrix or ISO/IEC 16022, the AS9132 standard (Data Matrix Quality Requirements for Parts Marking) by IAQG, and the ISO/IEC 15415 standard (Bar code symbol print quality test specification - Two-dimensional symbols). Additionally, to robustly measure the quality and predict the readability of the Data Matrix direct part marks, the patented DPM method is offered which measures several unique parameters that are pertinent to direct part marks.

The Base and System configurations are designed for use with PC systems running Windows 2000/XP. You can print or save to a file the verification results from the DMx Verifier+.

Base Configuration

- 0300 board
- Camera Cables
- DMx Verifier+ Software (CD only)
- DMx Verifier+ License Key
- DMx Verifier+™ User Manual

System Configuration

Note: Lighting is optional with the system configuration.

- 0300 board
- Camera Cables
- DMx Verifier+ Software (CD only)
- DMx Verifier+ License Key
- DMx Verifier+™ User Manual
- PC System including:
  - Windows 2000 or XP
  - 15” VGA Monitor
  - Keyboard & Mouse
- CM4000 Camera Kit, including:
  - Camera with Stand
  - 25mm Lens
  - Extension Tube Set
  - Cable

- MVi Camera/Light Imager (optional)

Scanning Options

The DMx Verifier+ is available with two scanning options:

- 0300 Board — Refer to the Camera I/O 0300 Card User Manual on your CD.
- MXi Reader — You can configure the DMx Verifier+ with the MXi Hand-Held Reader. The MXi has a female 9-pin serial connector that plugs into the PC's serial port, COM1 or COM2. The DMx Verifier+ establishes communications by detecting the correct COM port and baud rate used by the MXi. The DMx Verifier+ auto-detects baud rates from 9600 to 115200 (default). We recommend that the *highest stable* baud rate be used for optimum image uploading. Refer to the *MXi Reader User Manual* for comprehensive installation, setup, and user information on this product.

Note: Once the hardware and software installation have been completed, if communications fails with the MXi, you may need to run a check of the serial port(s) to restore serial communications. Refer to your PC owner's manual for guidance.

PC Requirements

- Pentium III processor 350 MHz or higher
- 128MB RAM
- 2GB hard disk (Enhanced IDE)
- SVGA display (800x600 w/256 colors)
- Disk Space (approximately 20MB free to install the software)
- Windows 2000 or XP

Software Installation

If you plan to install the 0300 board, you must install the software prior to installing the board.

To install or upgrade to DMx Verifier+ v2.0, double click the setup.exe icon in the DMx Verifier+ folder in the installation CD. Reboot as required. For upgrading, there is no longer a need to uninstall any previous version prior to upgrading to the new version.

If you are upgrading from previous versions of DMx Verifier+ with a 0300 board already installed, you only need to perform the Software Installation section to upgrade the software to version 2.0. When you need to install a new 0300 board, please follow the Hardware Installation section after first installing the software.

Installing Hardware

For first time installations, you need to complete the software installation before installing the hardware.

Basic Setup Procedures

The set-up and installation procedure for your DMx Verifier+ involves the following steps:

- Unpacking the 0300 board and DMx Verifier+ software
- Installing the 0300 board
- Installing the Camera Power cable
- Mounting the cameras
- Connecting all cables and power
- Installing the Software Protection Key (also called *Dongle*) to your PC's parallel or USB port

General Location Considerations

You can place the 0300 board in most environments without any concern for special enclosures or cabinets.

Consider the following when selecting your site:

- Ensure that the camera cable is long enough to reach your PC.
- Avoid severe vibrations.
- Locate the components to avoid accidental bumping.
- Protect your PC and components against dust, humidity, extreme temperatures, and extremely harsh environments.

Environmental Requirements

The environment of your PC is important for maintaining a reliable system. You should consider the humidity, temperature, foot traffic, and fresh air flow before permanently mounting your system.

- Fan Performance — 38 CFM minimum
- Typical Temperature Rise — 6.0°C, on every component on the 0300 board

Recommended Tools

You will need the tools listed below for the basic installation; you may need additional tools for custom installations.

- Small slotted screwdriver
- Small Phillips screwdriver
- Microscan-provided ESD ground strap

Installing the 0300 Board

Use the following procedure to install the 0300 board:

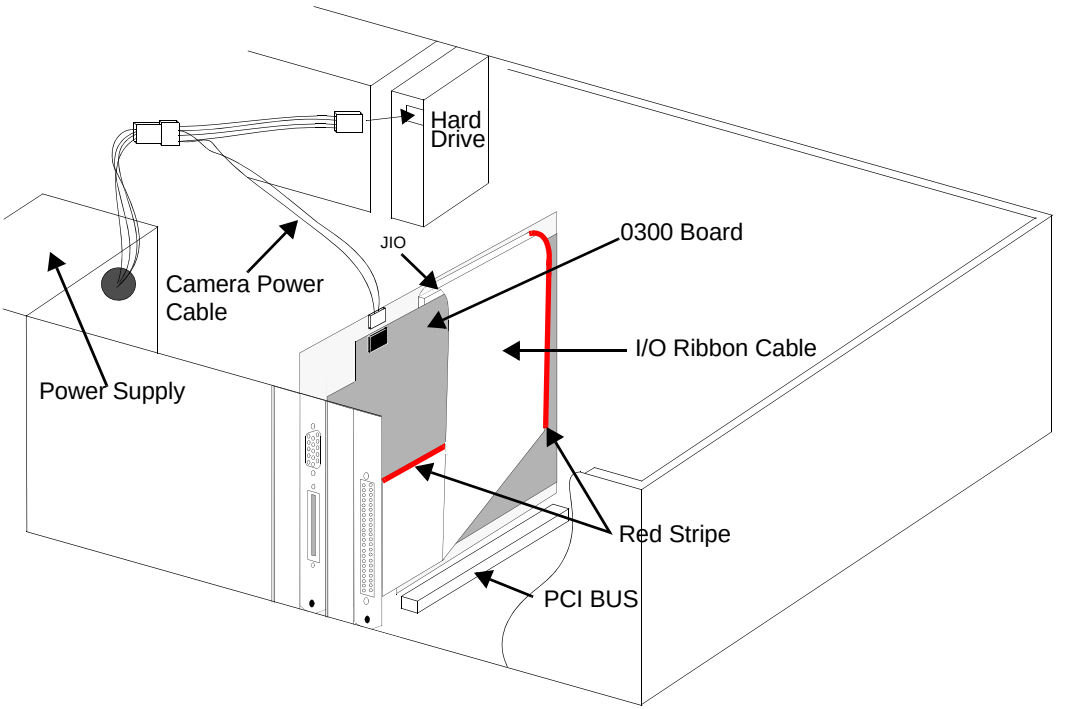
1. Remove the cover of your PC.
2. Locate an open PCI slot.
3. Unscrew the port access covers on the PC.
4. Install the 0300 board by aligning the gold fingers and pressing the module firmly into the slot.

5. Fasten the 0300 board with port access screws.

Installing the Internal Camera Power Cable

1. Connect the small connector of the internal Camera Power Cable to the Camera Power connector on the 0300 board, as shown in Figure 1–1.

FIGURE 1–1. Internal Cabling



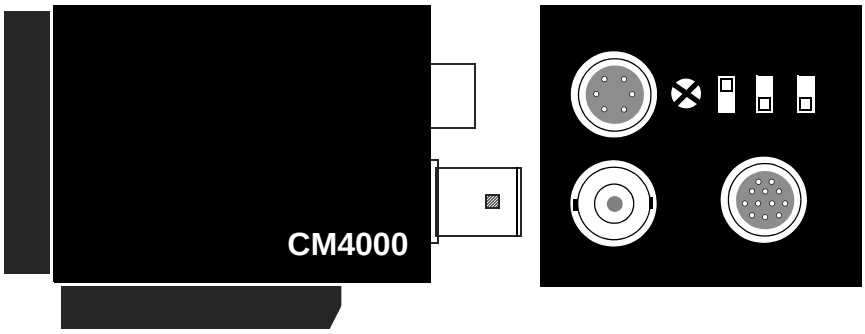
2. Connect the middle connector to an unused Hard Drive power cable in the PC.

Connecting the Camera Cable

Connect the adapter cable to the Camera Port on your PC. Connect the camera cable from the RS170 camera to the other end of the adapter.

Figure 1–2 shows an RS170 camera, a factory-modified CM4000 camera. The connectors at the rear of the camera supply power and sync to the camera, and send video from the camera to the 0300 board. The IRIS and VIDEO connectors are not used for normal operations. Set the switches to 1.0, MGC, and FRM.

FIGURE 1–2. CM4000 Camera



Camera Mount

The camera mount holds the camera in a fixed position. If the camera moves, the verification results may not be valid. Refer to Appendix B, “Creating A Good Image,” for more information.

Note: Mount the camera in a low-vibration environment. Otherwise, use a strobe in low ambient light.

Checklist

- Ensure that the camera is grounded only by the camera cable back to the camera port on the PC.

  The camera case is connected to the camera’s return circuit. This means that a camera affixed to an earth-grounded metallic fixture has the potential for creating a ground loop. A ground loop is an undesirable circuit created when grounds are connected at two or more locations. Return signals tend to flow through both ground circuits, which results in noise and/or distortion in the camera’s video signal.

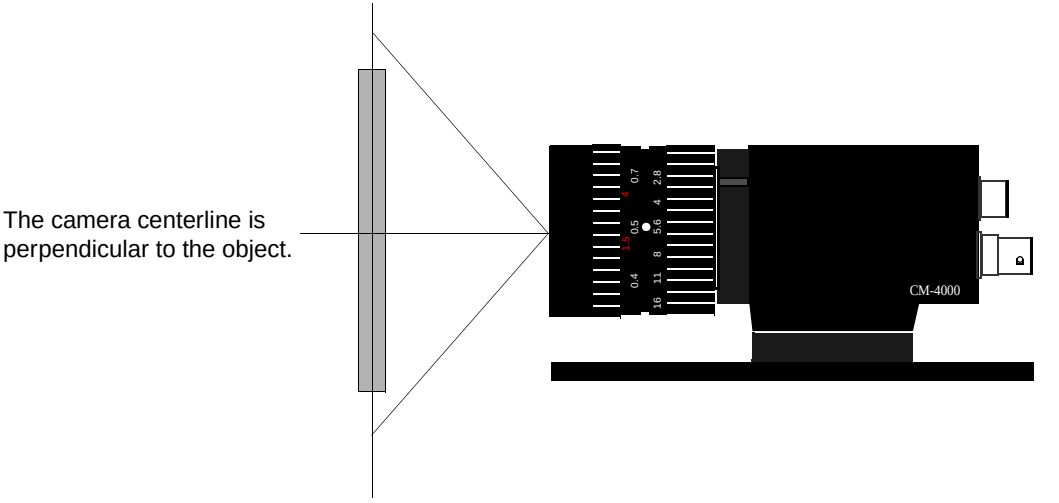
Isolate the camera's body from grounded fixtures. You could use plastic mounting bolts in conjunction with an insulating pad or mount the camera to a non-metallic mount and then install the camera/mount assembly as a unit.

- Position the camera to get the best Field of View (FOV), e.g., optimum viewing of the part and features. Please refer to Appendix B, "Creating A Good Image," for more information.
- If the camera needs to be adjusted in the X, Y, or Z axis, the mount must be able to adjust in those directions.
- Provide a way to clamp the lens to minimize image movement.
- Provide strain relief for the camera cable.
- Build a shroud to prevent accidental damage to the camera, and to prevent dirt or dust from getting on the lens.
- Ensure that the camera mount is strong enough to prevent bending if it is accidentally hit. Be sure to minimize or eliminate vibrations.

Ensuring the Best Field of View

It is best to mount the camera assembly so that its centerline is as near to perpendicular as possible to the desired FOV, as shown in Figure 1–3.

FIGURE 1–3. Camera Centerline



This reduces the chance of errors due to:

- Poor Depth of Field — The range of distance with acceptably sharp focus in front and back of the subject, is improper for the application.
- Foreshortening — One axis of the image appears shorter than another.

Where you mount your camera is important because it influences which lens you will use.

Adjusting the Camera Position

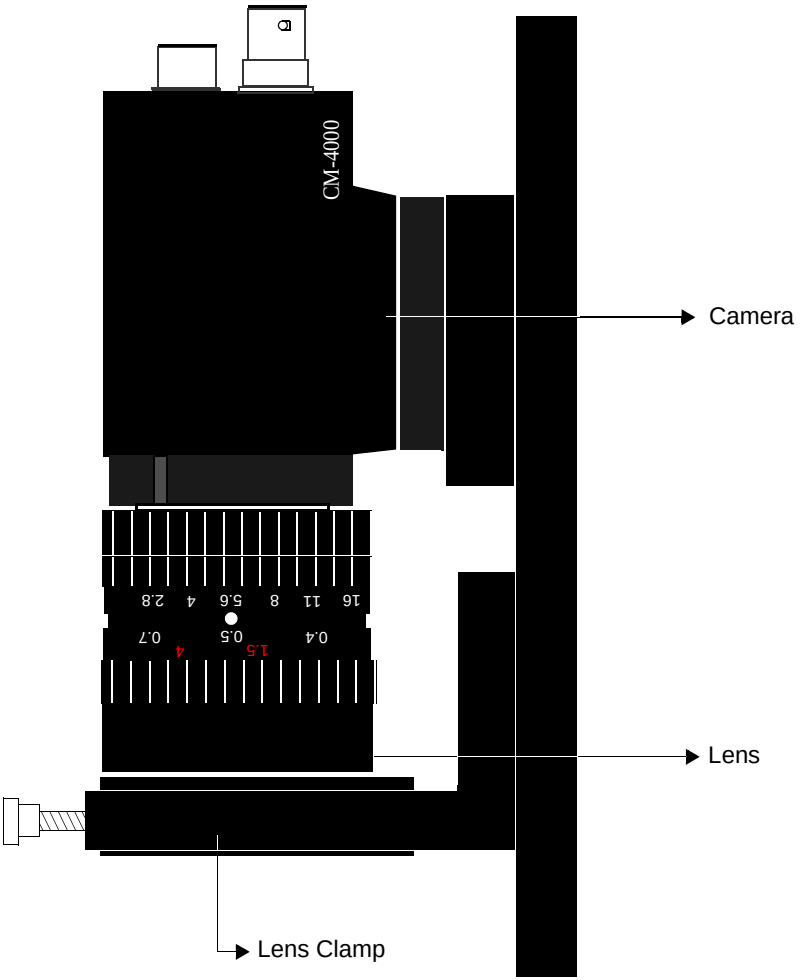
After you determine the best FOV for your application and the type of lens and its distance from the object being viewed, determine whether there is any need to move the camera. For example, you may be viewing different parts on one line, and each part may require a different X (horizontal), Y (vertical), or Z (in and out) position. Please refer to the Appendix B, “Creating A Good Image,” for more information.

The most common change is in the X and Y position. A screw-adjusted slide on the camera mount allows the best camera adjustment.

Clamping the Lens

Any lens movement, either by changing the focus or the f-stop, can seriously affect the verification results. Ensure that the lens cannot move once it has been set. The best method to inhibit movement is to clamp the lens, as shown in Figure 1–4. This will ensure that the focus and f-stop will not change, and should also prevent mechanical stress from being transferred to the camera.

FIGURE 1–4. Lens Clamp



Rebooting the System & Starting DMx Verifier+

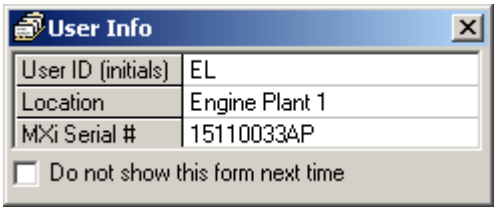
Prior to launching the DMx Verifier+ software:

1. Make sure the Software Protection Key (also referred to as the License Key or Dongle), is securely attached to the PC's parallel or USB port.
2. Select Start > Program Files > DMx Verifier+.

If the MXi Hand-Held Reader has been *physically connected* to the PC, it will beep several times in succession to confirm OK. The User Info dialog box will be displayed, as shown in Figure 1–5.

Note: This must be completed before you can run the software.

FIGURE 1–5. User Info Dialog Box



Note: This dialog box is only displayed when the MXi Hand-Held Reader is properly connected to the PC running the DMx Verifier+.

3. Type in the applicable information for:
   - User ID — Your initials.
   - Location — Physical location, PC name, etc.
   - MXi Serial # — This information is affixed to your MXi unit.

   We recommend that you leave the following box *unchecked*:
   - Do not show this form next time
4. Click OK when done.

You Are Done

At this point, you have performed the hardware installation and setup provided in this chapter and supplemented in the *MXi Hand-Held Reader User Manual*. You have also performed the software installation of the DMx Verifier+, Software Protection Key (Dongle), and 0300 driver. You are ready to use the software.

Consult Chapter 2, “DMx Verifier+ Overview” for detailed information on technical terminology and concepts related to the DMx Verifier+ verification measurements.

Use Chapter 3, “DMx Verifier+ Operations” as a guide to operate the software with the MXi Hand-Held Reader.

Refer to Chapter 4, “DMx Verifier+ Reference Guide” for complete descriptions of all menu options and features.

CHAPTER 2 DMx Verifier+ Overview

This chapter provides an overview of the verification standards supported by the DMx Verifier+.

Introduction

The DMx Verifier+ is a Windows-based system that performs Data Matrix print or mark quality verification. It provides a high level of validation of 2D Data Matrix code, verifying that direct part marks or labels have been properly applied and are readable. In addition to measuring and grading the Data Matrix quality based on current major marking or verification standards, the DMx Verifier+ offers the unique and patented DPM verification method, which reliably identifies any printing or marking problems and displays the marking errors in the Graphical User Interface (GUI) to enable the user to see and fix the errors.

DMx Verifier+ supports these verification or marking standards:

- AIM — For print quality verification of paper labels, the 2D Matrix Bar Code Print Quality – Guideline was traditionally used, which is described in the AIM Uniform Symbology Specification for Data Matrix released by AIM (Association for Automatic Identification and Mobility) in 1996. The document became ISO/IEC 16022, Information technology – Automatic identification and data capture techniques – Bar code symbology specifications – Data Matrix in 2000.
- IAQG — The SAE Standard AS9132, Data Matrix Quality Requirements for Parts Marking, was developed and published by IAQG (International

Aerospace Quality Group) in 2002. This marking standard covers three major processes:

  – Dot Peening

  – Laser Etching

  – Electro-Chem Etching

- ISO 15415 — The latest Data Matrix verification standard, ISO/IEC 15415, Information technology, Automatic identification and data capture techniques – Bar code symbol print quality test specification – Two-dimensional symbols, was released in 2004. For Data Matrix symbology, the standard covers both paper labels and direct part marks.

- DPM — The need for an effective verification method by the customers prompted Microscan to develop and patent in 1999 the unique verification methodology named DPM Verification. By incorporating and enhancing the parameters for paper labels from the AIM verification, Microscan further added several important parameters that have proven to be the most effective and reliable metric for judging the quality of direct part marks.

The DMx Verifier+ measures all parameters specified in all supported standards (AIM, ISO 15415, IAQG/AS 9132) and is compliant with these standards. It also provides other relevant information about the Data Matrix, such as Polarity, Symbol Size, Error Correction Level, Image Style, and Encoded Data String.

Description of Measured Parameters

Nominal Cell (or Module) Size is referenced by all verification methods. Nominal Cell Size is the average value of the two values:

- X Nominal Cell Size — X Nominal Cell Size is the Data Matrix width in pixels divided by the number of columns.
- Y Nominal Cell Size — Y Nominal Cell Size is the Data Matrix height in pixels divided by the number of rows.

Although Nominal Cell Size is not a true print quality indicator, it shows whether the image has sufficient resolution to achieve acceptable measurement accuracy and repeatability. The minimum required is 5 pixels; 10 pixels or more is recommended.

AIM Verification (ISO 16022)

For paper labels, four parameters are measured and graded:

- Symbol Contrast
- Axial Nonuniformity
- Print Growth
- Unused Error Correction

The Overall Symbol Grade is the lowest of the parameter grades achieved from these four parameters.

Symbol Contrast (SC)

Symbol Contrast is the difference in reflectance (measured by grayscale values) between the light and dark cells of the symbol. The arithmetic mean of the darkest 10% of the pixels and that of the lightest 10% pixels within the Data Matrix area are computed. Symbol Contrast is the difference of the two means divided by the full gray scale range.

Note: Symbol Contrast is sensitive to the lighting change; thus, an uncalibrated value has little meaning.

To use this parameter properly, contrast calibration must be performed first. Symbol Contrast is graded as:

A if SC >= 75%
B if SC >= 55%
C if SC >= 40%
D if SC >= 20%
if SC < 20%

Axial Nonuniformity (AN)

Axial Nonuniformity measures how different the average spacing between centers of adjacent cells in horizontal axis is from that of vertical axis. A square Data Matrix with the same number of rows and columns tends to look like a rectangular Data Matrix if Axial Nonuniformity is significant. Axial Nonuniformity is graded as:

A if AN <= 0.06
B if AN <= 0.08
C if AN <= 0.10
D if AN <= 0.12
F if AN > 0.12

Print Growth (PG)

Print Growth measures how much the cells comprising the Data Matrix have grown or shrunk from nominal cell size. X Print Growth and Y Print Growth are computed by sampling the centerlines of two alternating patterns (timing borders) respectively. Print Growth is the X or Y print growth that has the larger absolute value. In the AIM Specification or ISO 16022, a D' value was introduced such that D' = 3.3 x PG. The grade for Print Growth is:

A if |D'| <= 0.50
B if |D'| <= 0.70
C if |D'| <= 0.85
D if |D'| <= 1.00
F if |D'| > 1.00

Unused Error Correction (UEC)

A Data Matrix symbol has fixed error correction capacity. When a Data Matrix is decoded, the Error Correction used indicates how much of the error correction capability is consumed in order to decode the symbol. The more the error

correction is used, the less Unused Error Correction is left within the error correction capacity. The grade is:

A if UEC >= 0.62
B if UEC >= 0.50
C if UEC >= 0.37
D if UEC >= 0.25
F if UEC < 0.25

Overall Symbol Grade

The Overall Symbol Grade is the lowest of the parameter grades achieved from Symbol Contrast, Axial Nonuniformity, Print Growth, and Unused Error Correction.

IAQG Verification (AS9132, Rev A)

For direct part marks, dot peen marks in particular, four parameters are measured and graded:

- Dot Size
- Dot Center Offset
- Angle of Distortion
- Ovality

The Overall Symbol Grade is the lowest of the parameter grades achieved from Dot Size, Dot Center Offset, Angle of Distortion, and Ovality. Module Fill and Symbol Contrast are displayed but not graded.

Dot Size

No more than 2% of the total number of modules may contain dots that are outside the range of 60% to 105% of the nominal module size. Dot Size is graded as:

A if no more than 2% is outside the range of 70% to 90%
B if no more than 2% is outside the range of 60% to 105%
F if more than 2% is outside the range of 60% to 105%

To visualize the Dot Size error, the DMx Verifier+ marks:

- Green — Modules with Dot Size within the range of 70% and 90%
- Yellow — Modules with Dot Size outside the range of 70% and 90% but within the range of 60% to 105%
- Red — Modules with Dot Size outside the range of 60% and 105%

Dot Center Offset

No more than 2% of the total number of modules may contain dots whose dot center offset exceeds 20% of the nominal module size. Dot Center Offset is graded as:

A if no more than 2% is outside the range of 10%
B if no more than 2% is outside the range of 20%
F if more than 2% is outside the range of 20%

To visualize the Dot Center Offset error, the DMx Verifier+ marks:

- Green — Modules with Dot Center Offset within the range of 10%
- Yellow — Modules with Dot Center Offset outside the range of 10% but but within the range of 20%
- Red — Modules with Dot Center Offset outside the range of 20%

Angle of Distortion

Angle of Distortion requires that angular deviation of 90-degree axes between row and column shall not exceed ±7°. Angle of Distortion is graded as:

A if angular deviation does not exceed ±3.5°
B if angular deviation does not exceed ±7.0°
F if angular deviation exceed ±7.0°

Ovality

No more than 2% of the total number of modules may have ovality exceeding 20% of the nominal module size. Ovality is graded as:

B if no more than 2% is outside the range of 20%
F if more than 2% is outside the range of 20%

Module Fill

Module Fill is computed in both X and Y directions. X Module Fill is the average module width divided by X Nominal Module Size. Y Module Fill is the average module height divided by Y Nominal Module Size. Module Fill is not a graded parameter and is provided for reference only.

Symbol Contrast

Symbol Contrast is defined as the gray density difference between the marking and its substrate. For image based contrast measurement, the camera system first must be calibrated to match the Scale of Gray Density chart shown in AS9132. The contrast is then measured as the difference in reflectance (measured by grayscale values) between the light and dark modules of the symbol. The arithmetic mean of the darkest 10% of the pixels and that of the lightest 10% pixels within the Data Matrix area are computed. Symbol Contrast is the difference of the two means divided by the full gray scale range.

Overall Grade

The Overall Grade is the lowest of the parameter grades achieved from Dot Size, Dot Center Offset, Angle of Distortion, and Ovality.

ISO 15415 Verification

The Data Matrix verification based on ISO/IEC 15415 measures and grades these parameters:

- Reference Decode
- Symbol Contrast
- Axial Nonuniformity
- Grid Nonuniformity
- Unused Error Correction
- Fixed Pattern Damage
- Modulation

Print Growth is measured but not graded. Because Modulation requires modulation scores to be computed for each codeword used in the Reed-Solomon error correction process, ISO 15415 verification is only applicable to ECC200 Data Matrix.

Reference Decode

The symbology Reference Decode Algorithm decodes the Data Matrix. Reference Decode is graded as:

A if the Data Matrix is successfully decoded
F if the Data Matrix cannot be decoded

Symbol Contrast (SC)

Symbol Contrast is the difference between the highest and lowest reflectance values in the Data Matrix area including the quiet zone. It is graded as:

A if SC >= 70%
B if SC >= 55%
C if SC >= 40%
D if SC >= 20%
F if SC < 20%

Axial Nonuniformity (AN)

Note: The parameter is measured and graded according to the AIM specification.

Axial Nonuniformity measures how different the average spacing between centers of adjacent cells in horizontal axis is from that of vertical axis. A square

Data Matrix with the same number of rows and columns tends to look like a rectangular Data Matrix if Axial Nonuniformity is significant. Axial Nonuniformity is graded as:

A if AN <= 0.06
B if AN <= 0.08
C if AN <= 0.10
D if AN <= 0.12
F if AN > 0.12

Grid Nonuniformity (GN)

Grid Nonuniformity measures and grades the largest vector deviation of the grid intersections from their ideal theoretical position. The grid intersections are determined by the reference decode algorithm from the binarized image of the Data Matrix from the cells within the alternating patterns only. Grid Nonuniformity is graded as:

A if GN <= 0.38
B if GN <= 0.50
C if GN <= 0.63
D if GN <= 0.75
F if GN > 0.75

Unused Error Correction (UEC)

Note: The parameter is measured and graded according to the AIM specification.

A Data Matrix symbol has fixed error correction capacity. When a Data Matrix is decoded, the Error Correction used indicates how much of the error correction capability is consumed in order to decode the symbol. The more the error correction is used, the less Unused Error Correction is left within the error correction capacity. The grade is:

A if UEC >= 0.62
B if UEC >= 0.50
C if UEC >= 0.37
D if UEC >= 0.25
F if UEC < 0.25

Fixed Pattern Damage

Fixed Pattern Damage is measured based on modules in each of the four fixed patterns (two solid borders and two alternating patterns or timing borders) and its corresponding quiet zone, and when present, modules in or around the internal alignment patterns. Up to five segments are individually graded and then the "average grade" is determined. Finally, the grade for Fixed Pattern Damage is chosen to be the lowest of the segment grades and the average grade. There is no final value for Fixed Pattern Damage that corresponds to the grade for reporting.

Modulation

Modulation is a measure of the uniformity of reflectance of the dark and light modules, respectively. First, Modulation for each codeword is computed and graded based on the reflectance value of each module in the codeword. Then, the modulation grade is determined using codeword based modulation grades by applying an overlay procedure. There is no final value for Modulation to report.

Print Growth

Print Growth is measured the same way as in the AIM Verification but is not graded. It is reported as an informative measure for the purposes of process control.

Scan Grade

The scan grade for each scan or image is the lowest grade of all ISO 15415 parameters described in this section except for Print Growth.

Overall Grade

The overall grade is the average of the scan grades for all images of the same mark. DMx Verifier+ only takes one image and reports the overall grade. Therefore, the overall grade is the same as the scan grade.

DPM Verification

For direct part marks, the most useful parameters for marking quality control are Center Offset, Size Offset, Cell Modulation, and Print Growth. To make DPM Verification flexible enough to meet various custom verification requirements, additional complimentary parameters are taken from AIM and IAQG so that they can be measured at the same time. A total of 10 parameters can be enabled for measuring and grading.

Center Offset (CO)

Center Offset is a measure of the cell placement accuracy. The parameter is computed based on all On Cells of the Data Matrix. The On Cells are the cells having the same polarity or color as those on the two solid borders. The Off Cells are the cells in the Data Matrix that are not the On Cells. To measure Center Offset, first, the ideal Data Matrix grid with equally spaced cells in both axes is derived based on the outline of the Data Matrix symbol excluding the quiet zone. Then, the center of each cell in the ideal grid is determined. The geometric center of each On cell is also determined. The placement error for an On cell is the distance in pixels between the center of the On cell and its nearest center in the ideal grid. Center Offset is the sum of the placement errors of all On cells divided by the nominal cell size, then normalized to achieve the proper range between 0 and 10. Center Offset is non-negative with 0 being the best score, indicating no placement error, and a value greater than 5 indicating significant cell misplacement. Center Offset is graded as:

A if CO <= 2.5
B if CO <= 5.0
C if CO <= 7.5
D if CO <= 10.0
F if CO > 10.0

To visualize the placement error, the DMx Verifier+ marks:

- Green — Cells having the placement error between 0% and 15% of the nominal cell size
- Yellow — Cells having the placement error between 15% and 30% of the nominal cell size
- Red — Cells having the placement error >30% of the nominal cell size

Size Offset (SO)

Size Offset is a measure of the cell size or cell area uniformity of all On cells. To compute Size Offset, first the area of each On cell is computed based on edge locations of the cell. Then, the average area is computed. Finally, Size Offset is computed as the standard deviation of the areas of all On cells, divided by the square of the nominal cell size, and then normalized to achieve the proper range between 0 and 10. Size Offset is significant when there are many cells with varying sizes or shapes. Size Offset is non-negative with 0 being the best score, indicating no size variation, and a value greater than 5 indicating significant size variation. Size Offset is graded as:

A if SO <= 2.5
B if SO <= 5.0
C if SO <= 7.5
D if SO <= 10.0
F if SO > 10.0

To visualize the cell size or area variation, the DMx Verifier+ can optionally mark:

- Green — Cells whose areas do not exceed 15% of the average area
- Yellow — Cells whose areas are between 15% and 30% of the average area
- Red — Cells whose areas are more than 30% of the average area

Cell Modulation (CM)

Cell Modulation is a measure of the spread of the gray scale values of cells of the same polarity. On Cell Modulation is computed based on the standard deviation of grayscale values of all On cells. Off Cell Modulation is computed based on the standard deviation of grayscale values of all Off cells. To achieve good or high Cell Modulation, the standard deviation for On cells and Off Cells must be minimized, respectively. A Data Matrix mark with good Cell Modulation should produce an image such that all the dark cells have very similar low grayscale values and all the light cells have very similar high grayscale values. The Cell Modulation problem arises when the cells of the same polarity have large variations in grayscale values. In extreme cases, the grayscale values of some On cells can approach those of the Off cells and vice versa, which can make the determination of the cell polarity (i.e., if a cell is dark or light) more difficult. Cell Modulation is the smaller of On Cell Modulation and Off Cell Modulation. It has a range between 0 and 100% and is graded as:

A if CM >= 90%
B if CM >= 80%
C if CM >= 70%
D if CM >= 60%
F if CM < 60%

Border Match (BM)

Border Match is a measure of the quality of all four Data Matrix borders. It is computed as the number of border cells with correct polarity divided by the total number of border cells. When the border is perfect, Border Match is 100%. Border Match is a positive value that cannot exceed 100%. It is graded as:

A if BM >= 95%
B if BM >= 90%
C if BM >= 85%
D if BM >= 80%
F if BM < 80%

Symbol Contrast (SC)

Note: The parameter is measured and graded according to the AIM specification.

Symbol Contrast is the difference in reflectance (measured by grayscale values) between the light and dark cells of the symbol. The arithmetic mean of the darkest 10% of the pixels and that of the lightest 10% pixels within the Data Matrix area are computed. Symbol Contrast is the difference of the two means divided by the full gray scale range.

Note: Symbol Contrast is sensitive to the lighting change; thus, an uncalibrated value has little meaning.

To use this parameter properly, contrast calibration must be performed first. It is graded as:

A if SC >= 75%
B if SC >= 55%
C if SC >= 40%
D if SC >= 20%
F if SC < 20%

Axial Nonuniformity (AN)

Note: The parameter is measured and graded according to the AIM specification.

Axial Nonuniformity measures how different the average spacing between centers of adjacent cells in horizontal axis is from that of vertical axis. A square Data Matrix with the same number of rows and columns tends to look like a rectangular Data Matrix if Axial Nonuniformity is significant. The parameter is measured according to the AIM specification. Axial Nonuniformity is graded as:

A if AN <= 0.06
B if AN <= 0.08
C if AN <= 0.10
D if AN <= 0.12
F if AN > 0.12

Print Growth (PG)

Print Growth measures how much the Data Matrix cells are over or under printed/marked in both X and Y directions. X Print Growth (XPG) is computed as the difference between the average width of all On cells and the X Nominal Cell Size, divided by the X Nominal Cell Size. Y Print Growth (YPG) is computed as the difference between the average height of all On cells and the Y Nominal Cell Size, divided by the Y Nominal Cell Size. Print Growth (PG) is defined as the larger value of |XPG - TPG| and |YPG - TPG| where TPG is the Target Print Growth. Target Print Growth represents the best print growth value required for the marking application and is default to 0. For dot peen marks, you may choose to mark the dot size to be a certain percentage smaller than the nominal cell size and set the TPG to be a negative value such as -0.10 or -0.20. Print Growth is graded as:

A if PG <= 0.10
B if PG <= 0.20
C if PG <= 0.30
D if PG <= 0.40
F if PG > 0.40

Unused Error Correction (UEC)

Note: The parameter is measured and graded according to the AIM specification.

A Data Matrix symbol has fixed error correction capacity. When a Data Matrix is decoded, the Error Correction used indicates how much of the error correction capability is consumed in order to decode the symbol. The more the error correction is used, the less Unused Error Correction is left within the error correction capacity. The grade is:

A if UEC >= 0.62
B if UEC >= 0.50
C if UEC >= 0.37
D if UEC >= 0.25
F if UEC < 0.25

Angle of Distortion (AD)

Note: The parameter is measured according to the IAQG verification but graded differently.

Angle of Distortion is a measure of how much the “L” angle formed by the two solid borders deviates from the right angle. Angle of Distortion is graded as:

A if |AD| <= 2
B if |AD| <= 4
C if |AD| <= 6
D if |AD| <= 7
F if |AD| > 7

Overall Grade

The Overall Grade is the lowest grade received by all enabled verification parameters. By default, all parameters except for Nominal Cell Size and Symbol Contrast are enabled.

Verification Status

The Verification Status indicates Verification Pass/Fail or Verification Good/Fair/Poor. It is configured based on the individual parameter grade for DPM verification or the Overall Grade for AIM, ISO 15415, and IAQG verifications. The verification status is such that grade A is always Good and grade F is always Poor, and grade B, C, or D can be configured to be any of the Good, Fair, and Poor status as long as no lower grade is assigned a better status. If the Fair status is not used, then the verification status has two outcomes only, Good (or Pass) and Poor (or Fail).

For AIM, ISO 15415, and IAQG Data Matrix verification, the verification status is configured using the Overall Grade. The default configuration is grade B is Good, and grade C and D are Fair.

For DPM verification, the verification status is not configured using the Overall grade. Instead, the verification status for each parameter is configured individually and determined by the grade of the parameter. The default status configuration for each parameter is that grade B is Good, and grade C and D are Fair. The verification status for the DPM verification is chosen to be the lowest verification status of all enabled parameters.

Verification Guidelines and Examples

The goal of the Data Matrix quality verification is to ensure that the Data Matrix mark has sufficient quality and margin of error so that it can be read reliably over the service life of the part marked. DMx Verifier+ helps the user to achieve the goal by identifying and displaying the problems so they can be understood and corrected.

System Setup

To obtain accurate and repeatable verification results, you need to ensure that:

- The Data Matrix image is not saturated.
- The Data Matrix background is uniform in the image.
- The Data Matrix part surface is perpendicular to the camera axis.
- If the mark is not on a flat surface, the plane formed by the four corners of the Data Matrix is perpendicular to the camera axis.
- The Data Matrix image is in focus. Use a smaller aperture to increase the depth of focus.
- The nominal cell size of Data Matrix is at least 10 pixels in the image. A value between 5 and 10 may be acceptable depending on the edge sharpness obtained.

These factors are less important:

- Contrast — A lighter or darker image should yield similar quality measurements as long as the image is not saturated or too dark (i.e., contrast less than 20%)
- Position — The Data Matrix in the image does not have to be centered as long as the lighting is uniform and no significant lens distortion is present.

Parameter Considerations

General Parameters

Symbol Contrast measurement will change in direct correlation with changing factors affecting image acquisition. These factors include: type of lens, f-stops used, light source, position, and light intensity. To obtain and report consistent

Symbol Contrast, you should always perform the Contrast Calibration first. For AIM, IAQG, ISO 15415, and DPM, Symbol Contrast is computed similarly based on all the pixels in the Data Matrix area including the 1X Quiet Zone.

Axial Nonuniformity does not correlate well with the decodability. In general, marks with poor or failing Axial Nonuniformity grade are no more difficult to read than those with good Axial Nonuniformity grade for robust scanners. Nevertheless, it is a good idea to ensure good Axial Nonuniformity, especially since most of the marking methods are capable of producing marks with good Axial Nonuniformity grade. Axial Nonuniformity is computed and graded the same way for AIM, ISO 15415, and DPM.

Print Growth indicates whether the symbol is underprinted or overprinted. A mark with severe print growth or loss may become more difficult to read. For AIM, ISO 15415, Print Growth is measured based on the cells on the timing borders only. In DPM, all Data Matrix cells are used for computing Print Growth. It is not unusual for a DPM mark to have different growth or loss between border cells and internal cells. Therefore, Print Growth in DPM is a more accurate representation of the mark growth or loss.

Unused Error Correction measures the damage or defects in a Data Matrix mark. The grading is stable only if the errors are caused by “hard” damage where damaged cells are either very dark or very light. Cells with marginal grayscale values (neither dark nor light) may or may not consume error correction. This can cause a mark to have varying UEC grades even though the images of the mark have not changed much. In general, marks having poor UEC grades are bad marks, but it is possible that bad marks can get a good UEC grade. Modulation is a robust parameter that can help identify bad marks with good UEC grade.

IAQG/AS9132 Parameters

Dot Size and Dot Center Offset in IAQG are similar to Size Offset and Center Offset in DPM verification, respectively. Typically, the passing grade B in IAQG corresponds to Good grades (A or B) in DPM. There are many reasonable marks that earn a Fair grade (C or D) in DPM but would fail IAQG. Therefore, IAQG is very restrictive for dot peen marks.

IAQG does not measure the uniformity of reflectance of the dark and light cells or modules. This may not be a serious problem for dot peen marks but can allow poor laser or chemical etched marks to pass IAQG.

ISO 15415 Parameters

ISO 15415 verification relies on a single Modulation or Cell Modulation parameter to detect a number of problems such as print growth (or loss), cell misplacement, reflectivity of the substrate, uneven printing, etc. Since a low Cell Modulation grade can be caused by one of these problems or a combination of several problems, it is difficult to identify the exact problems, the magnitude of problems, and how they should be corrected.

DPM Parameters

Center Offset, Size Offset, and Cell Modulation are the three most important parameters for detecting problems unique to direct part marks. Although IAQG and ISO 15415 may have parameters with similar concept or names, these parameters in DPM are computed and graded in a more robust way. They also have wider ranges for quality assessment to allow a variety of marks failing IAQG or ISO 15415 to still receive the grade C or D in DPM. It has been proven that the marks with the grade C or D can be read reliably by higher performance Data Matrix scanners or readers.

Center Offset is an important parameter for marking methods such as dot peen and inkjet where the cell misplacement problem is more likely to happen.

Size Offset measures whether the On cells are produced in a uniform size. Problems such as pressure change in dot peening or power variation in laser etching can cause the cells to vary in size significantly.

Poor Cell Modulation can be caused by cell misplacement, cell size variation, and the optical characteristics of the substrate. If poor Cell Modulation is coupled with poor Center Offset and/or Size Offset, then the latter two problems must be corrected first. Poor Cell Modulation with acceptable Center Offset and Size Offset is a clear indication that the optical characteristics of the substrate and its response or reaction to the marking method must be improved in order to achieve more uniform cell reflectivity.

Examples of Data Matrix Verification

The following examples illustrate the strengths and weaknesses of each verification method. Typical dot peen and laser marks show how they are graded with these verification methods.

IAQG

IAQG is restrictive

1. A mark has to be near perfect to pass IAQG. It also receives good grades with DPM.

FIGURE 2–1. Dot Center Offset Display of the Dot Peen Mark

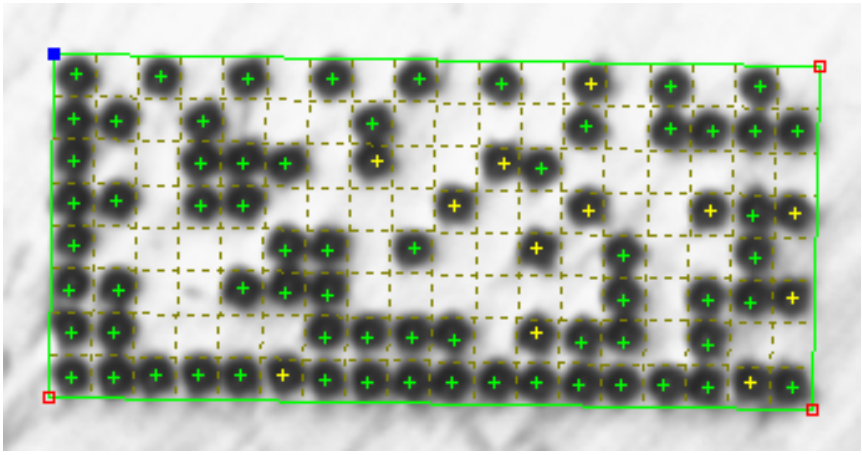


FIGURE 2–2. IAQG Results

Dot Size	B	over [70%..90%] = 54.2%, over [60%..105%] = 0.0%
Dot Center Offset	B	over 10% = 8.3%, over 20% = 0.0%
Angle of Distortion	A	0.0
Ovality	B	over 20% = 0.0%
Module Fill		X = 92%, Y = 91%
Symbol Contrast		78%
Nominal Module Size		17.1
Overall Grade	B	IAQG Status = Good

8511908097

FIGURE 2–3. DPM Results

Nominal Cell Size	A	17.1
Center Offset	B	3.0 [15..30%] = 4 , [> 30%] = 0
Size Offset	B	3.3 [15..30%] = 1 , [> 30%] = 0
Cell Modulation	A	On = 94%, Off = 90%
Border Match	A	100%
Symbol Contrast	A	78%
Axial Nonuniformity	A	0.00
Print Growth	A	X = -8%, Y = -9%
Unused Error Correction	A	1.00
Angle of Distortion	A	0.0
Overall Grade	B	DPM Status = Good

8511908097

2. A similar mark with slightly worse Dot Center Offset causes it to fail IAQG. It has the grade C by DPM since dots are smaller and have more variations in size.

FIGURE 2–4. Dot Center Offset of the Dot Peen Mark

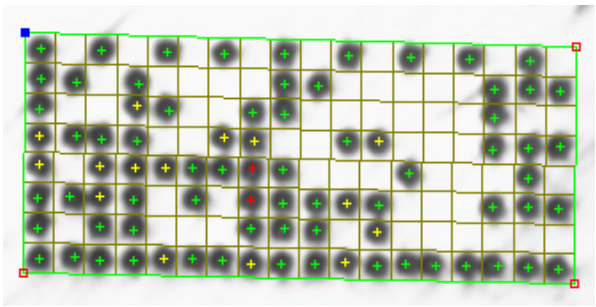


FIGURE 2–5. IAQG Results

Dot Size	B	over [70%..90%] = 11.8%, over [60%..105%] = 1.4%
Dot Center Offset	F	over 10% = 21.5%, over 20% = 2.1%
Angle of Distortion	A	1.0
Ovality	B	over 20% = 0.0%
Module Fill		X = 76%, Y = 79%
Symbol Contrast		70%
Nominal Module Size		16.9
Overall Grade	F	IAQG Status = Poor
8513107313		

FIGURE 2–6. DPM Results

Nominal Cell Size	A	16.9
Center Offset	B	4.7 [15..30%] = 13 , [> 30%] = 0
Size Offset	C	6.6 [15..30%] = 5 , [> 30%] = 1
Cell Modulation	A	On = 90%, Off = 97%
Border Match	A	100%
Symbol Contrast	A	70%
Axial Nonuniformity	A	0.02
Print Growth	C	X = -24%, Y = -21%
Unused Error Correction	A	1.00
Angle of Distortion	A	1.0
Overall Grade	C	DPM Status = Fair
8513107313		

3. Another mark fails IAQG with worse Dot Center Offset (9.7% of modules are over 20% placement error) but better Dot Size Offset (smaller percentages of modules over [70%..90%] and [60%..105%]). DPM reflects these changes in Center Offset and Size Offset.

FIGURE 2–7. Dot Center Offset Display of the Dot Peen Mark

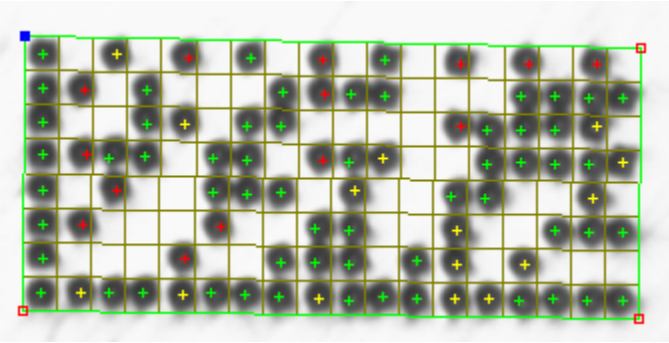


FIGURE 2–8. IAQG Results

Dot Size	B	over [70%..90%] = 2.1%, over [60%..105%] = 0.7%
Dot Center Offset	F	over 10% = 20.1%, over 20% = 9.7%
Angle of Distortion	A	1.0
Ovality	B	over 20% = 0.7%
Module Fill		X = 82%, Y = 86%
Symbol Contrast		73%
Nominal Module Size		17.0
Overall Grade	F	IAQG Status = Poor

8513109225

FIGURE 2–9. DPM Results

Nominal Cell Size	A	17.0
Center Offset	C	5.6 [15..30%] = 21 , [> 30%] = 1
Size Offset	B	3.9 [15..30%] = 4 , [> 30%] = 1
Cell Modulation	B	On = 89%, Off = 94%
Border Match	A	100%
Symbol Contrast	A	73%
Axial Nonuniformity	A	0.00
Print Growth	B	X = -18%, Y = -14%
Unused Error Correction	A	1.00
Angle of Distortion	A	1.0
Overall Grade	C	DPM Status = Fair

8513109225

4. Another example of a typical good dot peen mark that fails IAQG, receives suitable grade B due to moderate cell misplacement according to DPM.

FIGURE 2–10. Dot Center Offset Display of the Dot Peen Mark

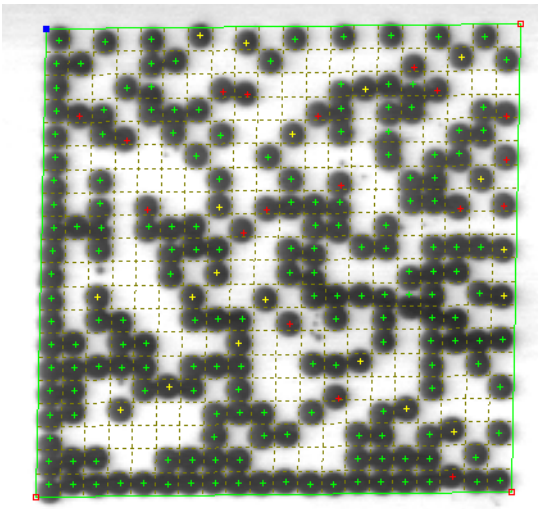


FIGURE 2–11. IAQG Results

Dot Size	F	over [70%..90%] = 53.3%, over [60%..105%] = 2.5%
Dot Center Offset	F	over 10% = 9.3%, over 20% = 4.5%
Angle of Distortion	A	-2.0
Ovality	B	over 20% = 0.3%
Module Fill		X = 98%, Y = 104%
Symbol Contrast		77%
Nominal Module Size		18.3
Overall Grade	F	IAQG Status = Poor
00122B56661397AXH		

FIGURE 2–12. DPM Results

Nominal Cell Size	A	18.3
Center Offset	B	4.6 [15..30%] = 17 , [> 30%] = 8
Size Offset	B	2.6 [15..30%] = 1 , [> 30%] = 0
Cell Modulation	B	On = 87%, Off = 83%
Border Match	A	100%
Symbol Contrast	A	77%
Axial Nonuniformity	A	0.01
Print Growth	A	X = -2%, Y = 4%
Unused Error Correction	A	0.89 (wrong cells: 1)
Angle of Distortion	A	-2.0
Overall Grade	B	DPM Status = Good

00122B56661397AXH

DPM

DPM Verification is accurate, sensitive, and robust

1. A good dot peen mark gets the grade B with DPM.

FIGURE 2–13. Unused Error Correction Display of the Dot Peen Mark

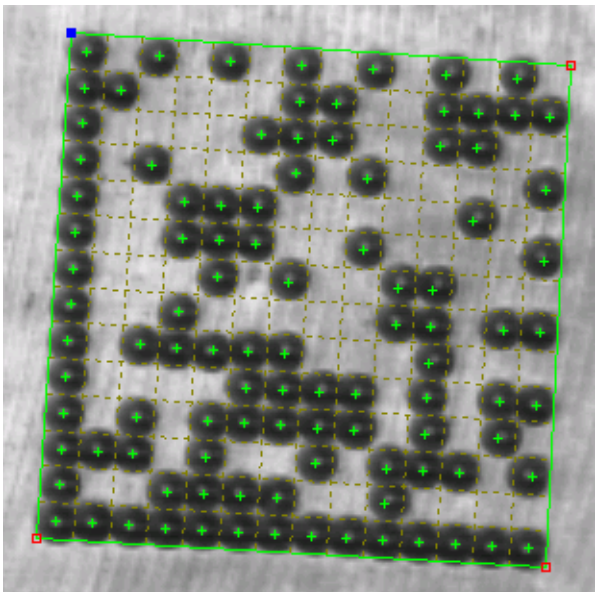


FIGURE 2–14. DPM Results

Nominal Cell Size	A	18.7
Center Offset	A	2.0 [15..30%] = 2 , [> 30%] = 0
Size Offset	A	2.3 [15..30%] = 0 , [> 30%] = 0
Cell Modulation	B	On = 92%, Off = 82%
Border Match	A	100%
Symbol Contrast	B	63%
Axial Nonuniformity	A	0.00
Print Growth	B	X = 7%, Y = 11%
Unused Error Correction	A	1.00
Angle of Distortion	A	-1.0
Overall Grade	B	DPM Status = Good

A00065MX

2. Another good dot peen mark gets the grade B with DPM.

FIGURE 2–15. Unused Error Correction Display of the Dot Peen Mark

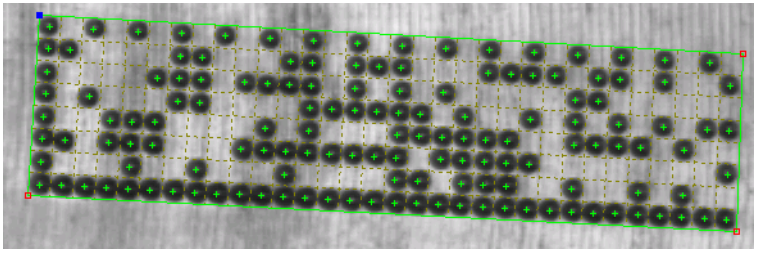


FIGURE 2–16. DPM Results

Nominal Cell Size		17.2
Center Offset	A	1.2 [15..30%] = 0 , [> 30%] = 0
Size Offset	B	3.8 [15..30%] = 3 , [> 30%] = 0
Cell Modulation	B	On = 92%, Off = 83%
Border Match	A	100%
Symbol Contrast		63%
Axial Nonuniformity	A	0.00
Print Growth	B	X = -14%, Y = -12%
Unused Error Correction	A	1.00
Angle of Distortion	A	-1.0
Overall Grade	B	DPM Status = Good

A00065MX

3. A good laser mark gets the grade B with DPM.

FIGURE 2–17. Unused Error Correction Display of the Laser Mark

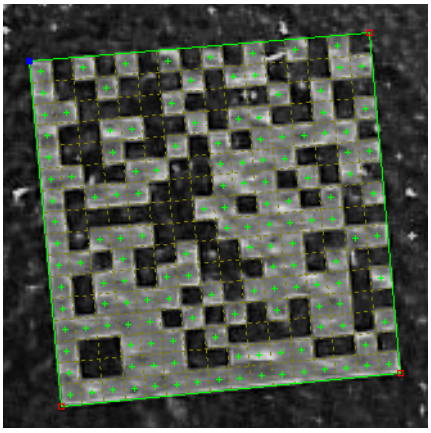


FIGURE 2–18. DPM Results

Nominal Cell Size	A	16.6
Center Offset	A	1.5 [15..30%] = 3 , [> 30%] = 0
Size Offset	B	3.2 [15..30%] = 3 , [> 30%] = 2
Cell Modulation	B	On = 84%, Off = 85%
Border Match	A	100%
Symbol Contrast	B	62%
Axial Nonuniformity	A	0.00
Print Growth	B	X = 2%, Y = 11%
Unused Error Correction	A	1.00
Angle of Distortion	A	-1.0
Overall Grade	B	DPM Status = Good
T 3482 N 00253		

4. A laser mark with significant Cell Modulation error in DPM due to significant background variation.

FIGURE 2–19. Unused Error Correction Display of the Laser Mark

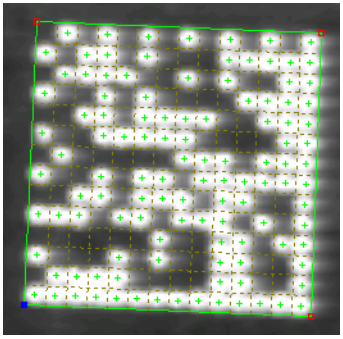


FIGURE 2–20. DPM Results

Nominal Cell Size	A	15.8
Center Offset	A	1.2 [15..30%] = 0 , [> 30%] = 0
Size Offset	C	5.4 [15..30%] = 8 , [> 30%] = 0
Cell Modulation	C	On = 94%, Off = 78%
Border Match	A	100%
Symbol Contrast	A	73%
Axial Nonuniformity	A	0.00
Print Growth	B	X = -13%, Y = -7%
Unused Error Correction	A	1.00
Angle of Distortion	A	0.0
Overall Grade	C	DPM Status = Fair

123456789012345

5. A laser mark with significant Size Offset error in DPM due to significant cell size variations.

FIGURE 2–21. Size Offset Display of the Laser Mark

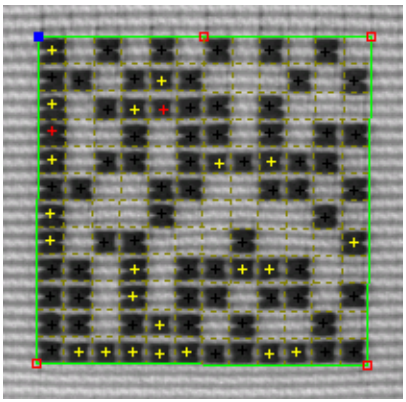


FIGURE 2–22. DPM Results

Nominal Cell Size	A	14.3
Center Offset	B	3.6 [15..30%] = 4 , [> 30%] = 0
Size Offset	D	8.3 [15..30%] = 22 , [> 30%] = 2
Cell Modulation	A	On = 93%, Off = 95%
Border Match	A	100%
Symbol Contrast	B	59%
Axial Nonuniformity	A	0.01
Print Growth	B	X = -18%, Y = -18%
Unused Error Correction	A	1.00
Angle of Distortion	A	0.0
Overall Grade	D	DPM Status = Fair

0123456789

6. A challenging but readable laser mark with significant Cell Modulation and Print Growth problems shown in DPM.

FIGURE 2–23. Unused Error Correction Display of the Laser Mark

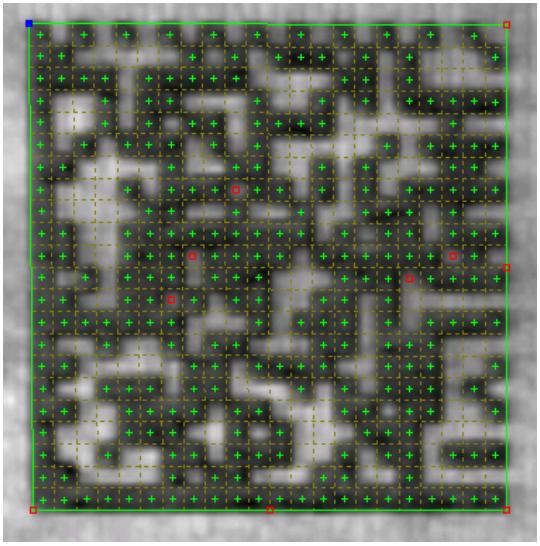


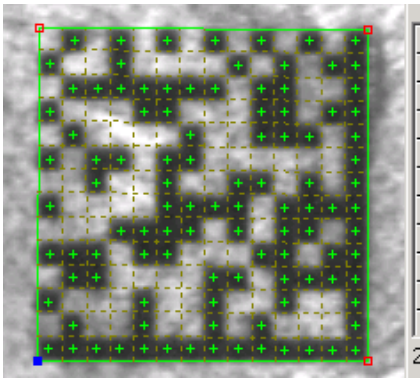
FIGURE 2–24. DPM Results

Nominal Cell Size	A	15.4
Center Offset	A	2.5 [15..30%] = 7 , [> 30%] = 2
Size Offset	C	5.9 [15..30%] = 5 , [> 30%] = 1
Cell Modulation	D	On = 86%, Off = 66%
Border Match	A	100%
Symbol Contrast	C	52%
Axial Nonuniformity	A	0.02
Print Growth	D	X = 26%, Y = 34%
Unused Error Correction	A	0.65 (wrong cells: 5)
Angle of Distortion	A	0.0
Overall Grade	D	DPM Status = Fair
PNR PDCR300-1640-M1 MFD 09/00		

Cell Modulation is more stable than UEC

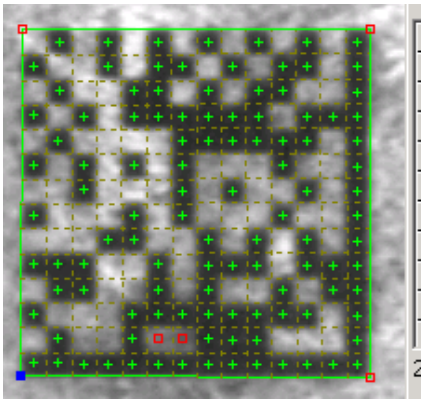
Cell Modulation is a more stable parameter than UEC. Below, three laser marks of similar quality received different UEC grades A (1.00), B (0.60), and C (0.40) but more consistent CM grades C (75%), D (69%), and D (66%) respectively.

FIGURE 2–25. UEC Display of Laser Marks & DPM Results



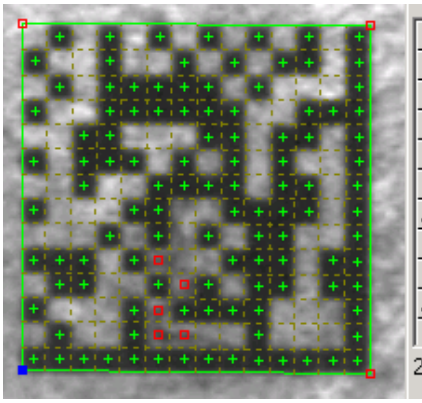
Nominal Cell Size		13.2
Center Offset	A	0.9 [15..30%] = 0 , [> 30%] = 0
Size Offset	B	3.0 [15..30%] = 1 , [> 30%] = 0
Cell Modulation	C	On = 95%, Off = 75%
Border Match	A	100%
Symbol Contrast		65%
Axial Nonuniformity	A	0.00
Print Growth	A	X = 5%, Y = 2%
Unused Error Correction	A	1.00
Angle of Distortion	A	0.0
Overall Grade	C	DPM Status = Fair

260604012006261



Nominal Cell Size		13.3
Center Offset	A	0.8 [15..30%] = 0 , [> 30%] = 0
Size Offset	B	3.0 [15..30%] = 1 , [> 30%] = 0
Cell Modulation	D	On = 95%, Off = 69%
Border Match	A	100%
Symbol Contrast		62%
Axial Nonuniformity	A	0.00
Print Growth	A	X = 4%, Y = 2%
Unused Error Correction	B	0.60 (wrong cells: 2)
Angle of Distortion	A	0.0
Overall Grade	D	DPM Status = Fair

260604011758571



Nominal Cell Size		13.3
Center Offset	A	0.6 [15..30%] = 0 , [> 30%] = 0
Size Offset	B	4.0 [15..30%] = 4 , [> 30%] = 0
Cell Modulation	D	On = 95%, Off = 66%
Border Match	A	100%
Symbol Contrast		57%
Axial Nonuniformity	A	0.00
Print Growth	A	X = 7%, Y = -1%
Unused Error Correction	C	0.40 (wrong cells: 5)
Angle of Distortion	A	-1.0
Overall Grade	D	DPM Status = Fair

260604011918391

UEC is stable with hard damage

UEC is stable for “hard” damage caused by damaged or missing cells. In this case, DPM usually has the same UEC value and grade.

FIGURE 2–26. Unused Error Correction Display of the Laser Mark

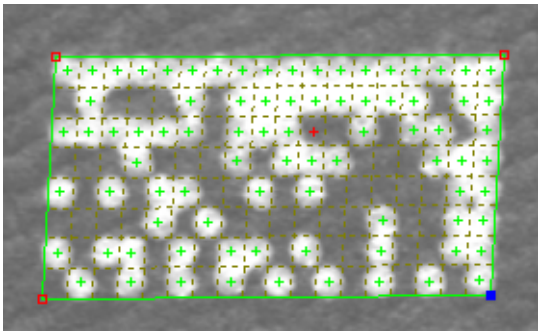


FIGURE 2–27. DPM Results

Nominal Cell Size	A	14.3
Center Offset	A	2.5 [15..30%] = 2 , [> 30%] = 1
Size Offset	B	2.9 [15..30%] = 0 , [> 30%] = 0
Cell Modulation	C	On = 76%, Off = 94%
Border Match	A	100%
Symbol Contrast	B	56%
Axial Nonuniformity	F	0.19
Print Growth	B	X = 15%, Y = -4%
Unused Error Correction	A	0.72 (wrong cells: 1)
Angle of Distortion	B	-3.0
Overall Grade	F	DPM Status = Poor

12345678

3

CHAPTER 3 DMx Verifier+ Operations

This chapter explains how to operate the DMx Verifier+ with the MXi interface. Sample bitmap images, mentioned in this overview, are provided with your installation software. We recommend that you consult Chapter 4 as necessary for complete descriptions of all product functionality.

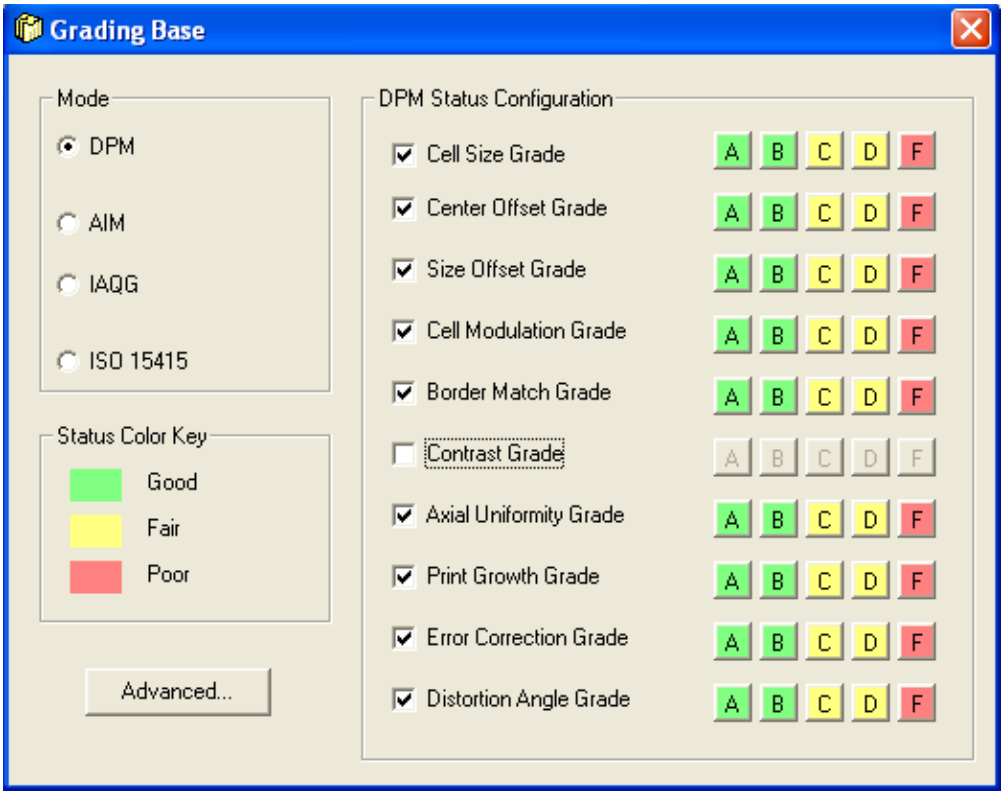
Note: This chapter serves as a guide. Your results may vary.

Verifier Operations

Auto Check

Auto Check performs the full verification process to obtain the measurement results. The following sample images explain how to use the Verifier to measure the print quality based on DPM. Select the DPM grading base and use the default options in DPM Status Configuration, as shown in Figure 3–1:

FIGURE 3–1. Grading Base

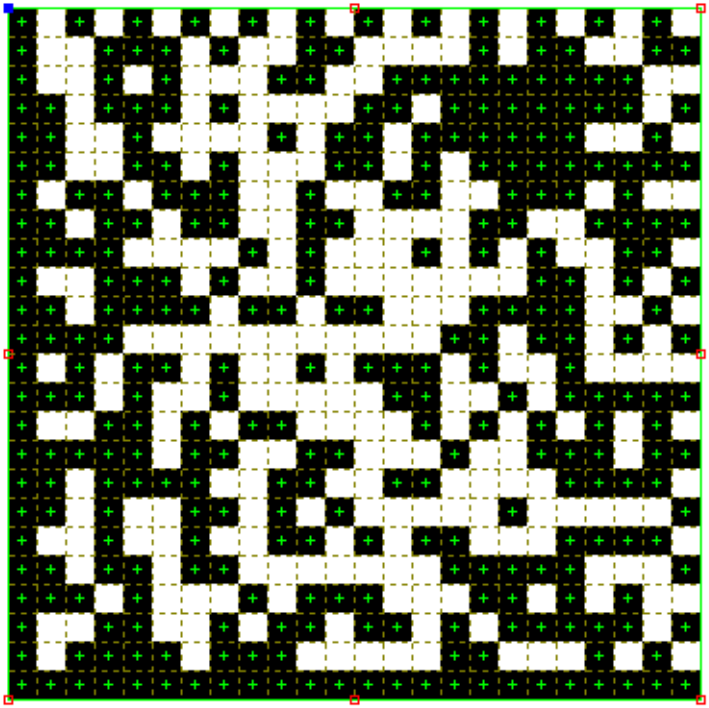


Sample 1 — Perfect Data Matrix Image

Open the file sample1.bmp from the Help folder under the application directory (the default directory is C:\Program Files\DMx Verifier+). Select Tools > Auto Check to perform the verification. When the verification process is completed, the main window shows the error correction graphic display. The correct On cells are marked in green plus signs, as shown in Figure 3–2.

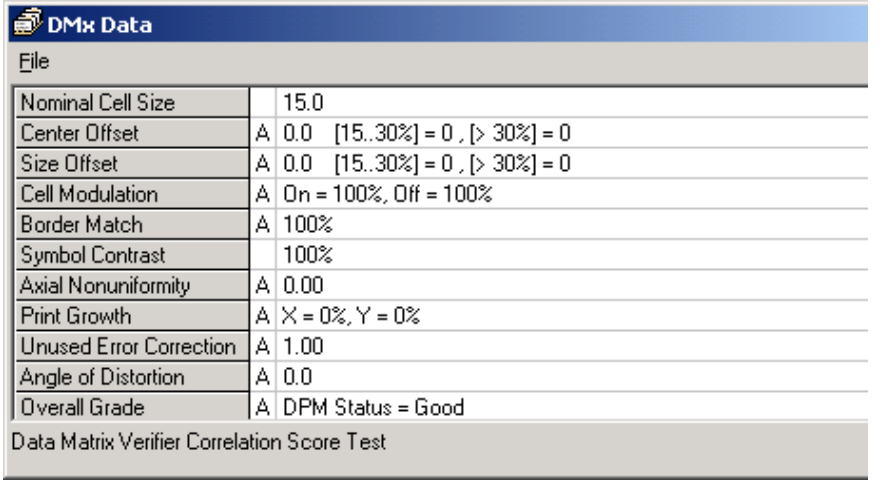
Note: The small red squares touching the Data Matrix borders are not part of the error correction graphic display.

FIGURE 3–2. Perfect Data Matrix Image



If the Zoom tool bar or the Zoom menu under View menu is enabled, then you can select it to obtain a larger display of the Data Matrix. In this example, the Data Matrix is big in the image and no magnification is allowed. The measurement results are also displayed in a DMx Data window, as shown in Figure 3–3:

FIGURE 3–3. DMx Data Window


DMx Data
File
Nominal Cell Size 15.0
Center Offset A 0.0 [15..30%] = 0 , [> 30%] = 0
Size Offset A 0.0 [15..30%] = 0 , [> 30%] = 0
Cell Modulation A On = 100%, Off = 100%
Border Match A 100%
Symbol Contrast 100%
Axial Nonuniformity A 0.00
Print Growth A X = 0%, Y = 0%
Unused Error Correction A 1.00
Angle of Distortion A 0.0
Overall Grade A DPM Status = Good
Data Matrix Verifier Correlation Score Test

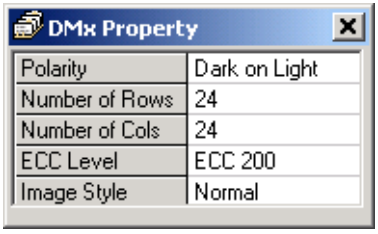
Only enabled parameters have grade displayed proceeding the measurement values. The following information explains the various fields in the DMx Data window:

- **Nominal Cell Size** is 15 pixels and was not enabled for grading. To obtain good measurement results, a minimum of 5 pixels is required. We recommend that the camera's FOV be set such that the nominal cell size is at least 10 pixels.
- **Center Offset** is 0.0 and has the grade A. This value alone tells that there is no cell center misplacement problem. Additionally, there are no cells that have placement errors between 15% and 30% or more than 30% of the nominal cell size.
- **Size Offset** is 0.0 and has the grade A. This value alone tells that there is no cell size offset problem. Additionally, there are no cells that have size errors between 15% and 30% or more than 30% of the average cell area.
- **% Cell Modulation** is 100% for On and Off cells respectively and has the grade A. This score shows that all On cells have the same grayscale value and all Off cells have the same grayscale value.
- **% Border Match** is 100% and has the grade A. This value tells there is no border damage.
- **% Contrast** is 100% and was not enabled for grading.

- **Axial Uniformity** is 0 and has the grade A.
- **Print Growth** is 0% in X direction and 0% in Y direction and has the grade A.
- **Unused Error Correction** is the maximum value of 1.00 and has the grade A.
- **Angle of Distortion** is 0.0 and has the grade A.
- **Overall Grade** is A which is the lowest grade of all enabled parameters in the Grading Base box. The status for DPM verification is Good.

You can display other Data Matrix properties from the View > DMx Property menu item, as shown in Figure 3–4.

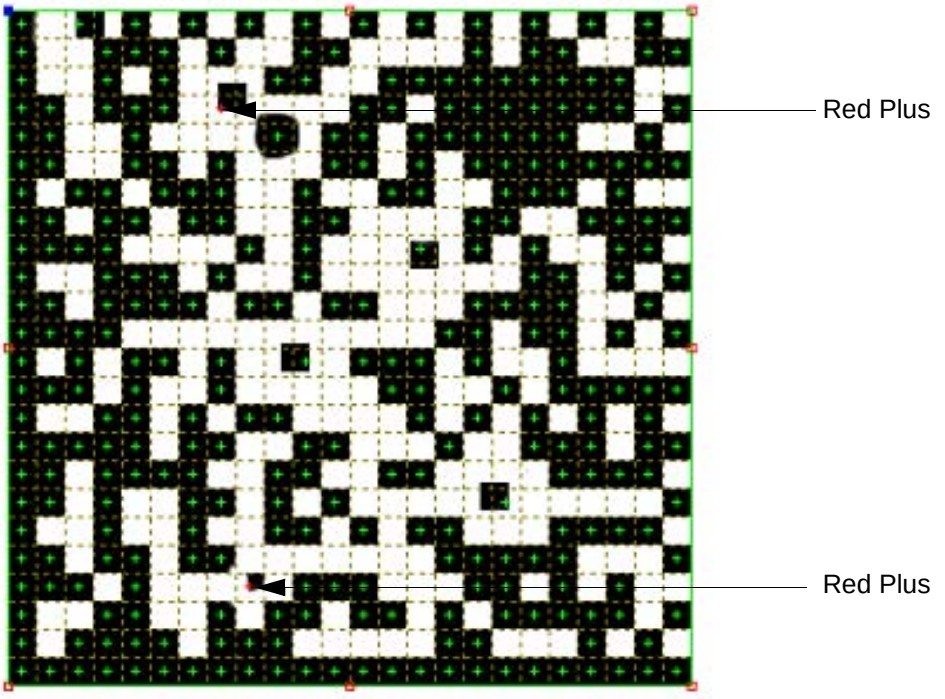
FIGURE 3–4. DMx Property Dialog Box



Sample 2 — Data Matrix with Errors

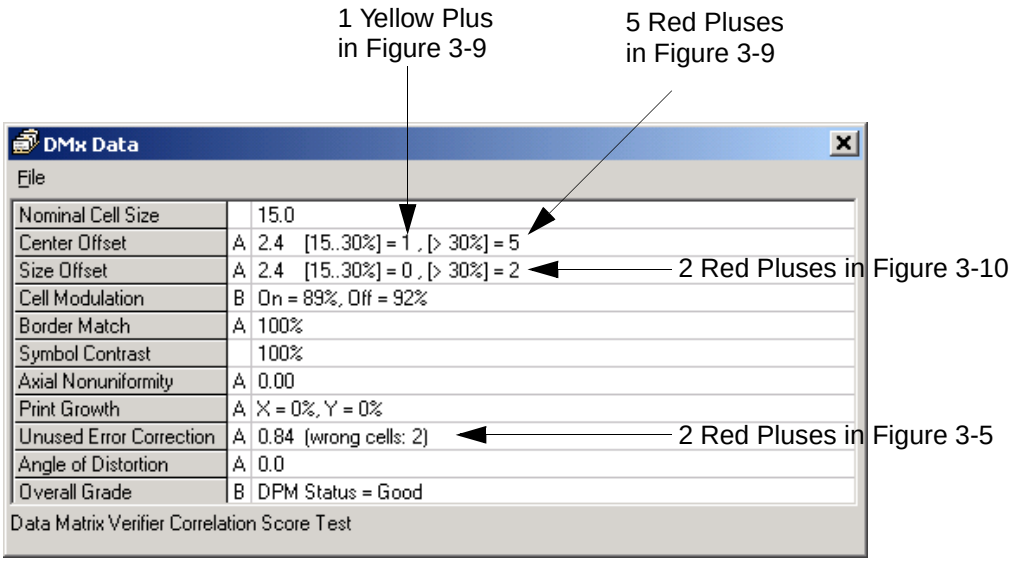
The Data Matrix in sample2.bmp (Figure 3–5) contains cells that have center offset or size offset errors. Open sample2.bmp; then select Auto Check. By default, the graphic representation of error correction is displayed in the main window.

FIGURE 3–5. Data Matrix With Error Correction Used



The DMx Data window displays the verification results, as shown in Figure 3–6.

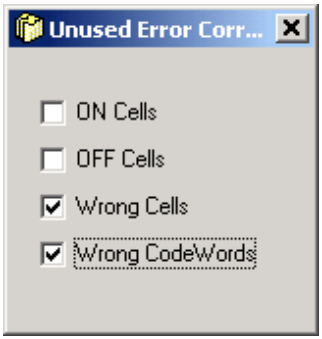
FIGURE 3–6. Verification Results


1 Yellow Plus
in Figure 3-9
5 Red Pluses
in Figure 3-9
DMx Data
File
Nominal Cell Size 15.0
Center Offset A 2.4 [15..30%] = 1 , [> 30%] = 5
Size Offset A 2.4 [15..30%] = 0 , [> 30%] = 2
2 Red Pluses in Figure 3-10
Cell Modulation B On = 89%, Off = 92%
Border Match A 100%
Symbol Contrast 100%
Axial Nonuniformity A 0.00
Print Growth A X = 0%, Y = 0%
Unused Error Correction A 0.84 (wrong cells: 2)
2 Red Pluses in Figure 3-5
Angle of Distortion A 0.0
Overall Grade B DPM Status = Good
Data Matrix Verifier Correlation Score Test

In the main window, the two cells in the ideal grid whose centers are marked with a red plus are two On cells that were incorrectly identified as Off cells. They correspond to the Unused Error Correction of 0.84 and the two wrong cells displayed in the DMx Data window.

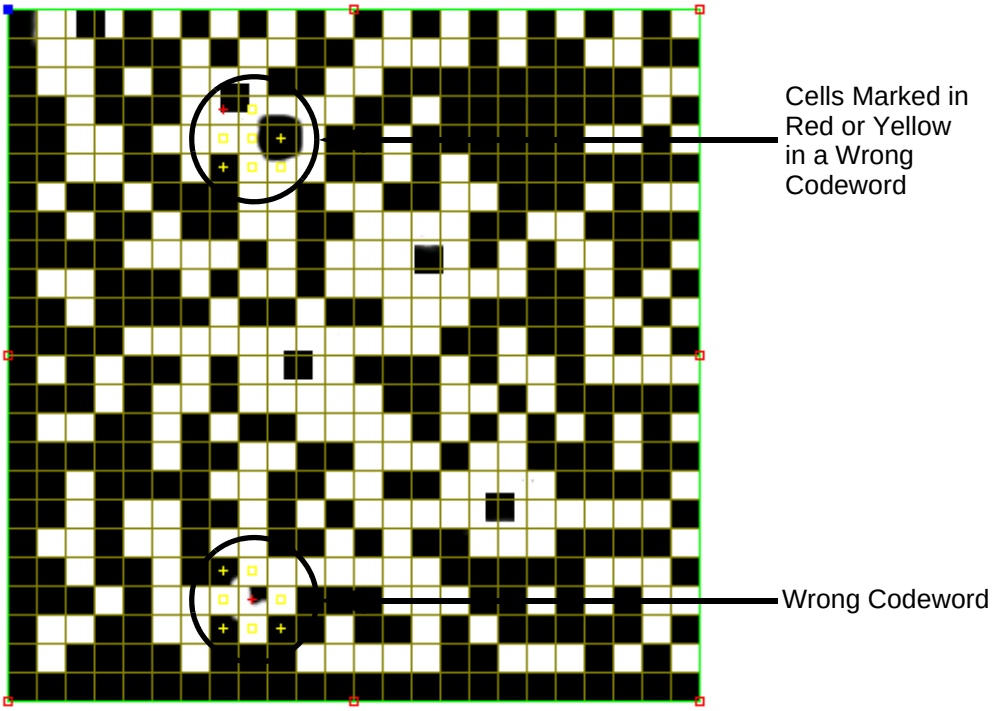
To view the wrong cells and their associated codewords in the main window, left double click on the Unused Error Correction field in the DMx Data window to bring up the Unused Error Correction dialog box. Uncheck ON Cells and check Wrong CodeWords.

FIGURE 3–7. Unused Error Correction Dialog Box



In the main window, the two misidentified cells are marked in a red plus for On cells. The rest of the cells in the two corresponding codewords are now marked with a yellow plus and a yellow square respectively, as shown in Figure 3–8.

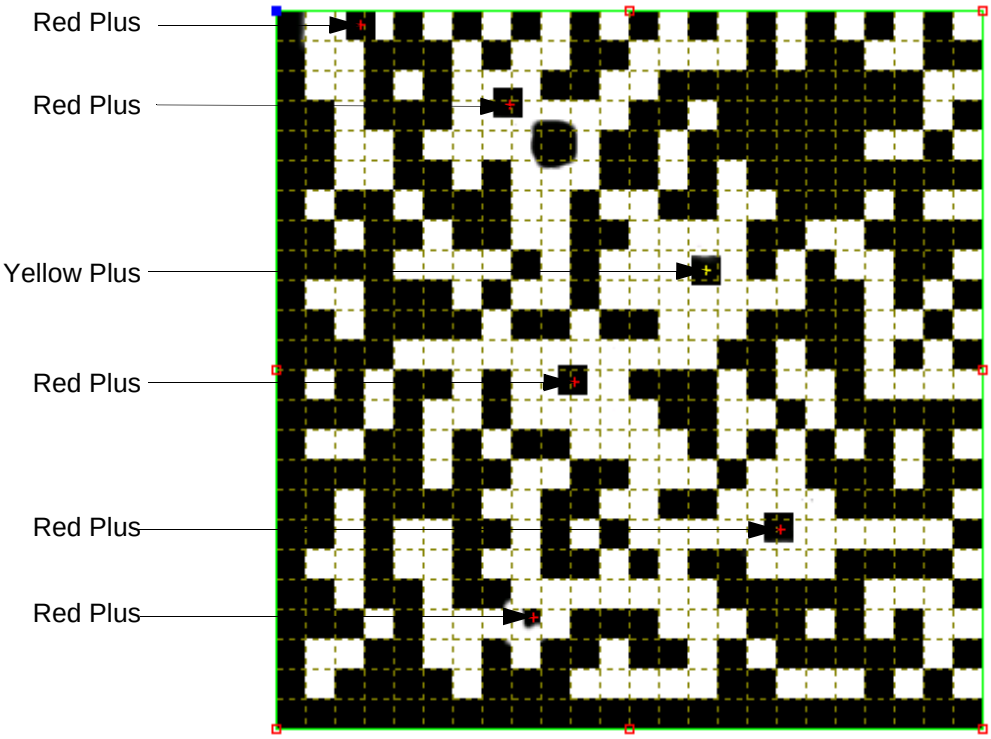
FIGURE 3–8. Data Matrix with Wrong Codewords



The Center Offset is 2.4, a value indicating a minor center offset problem. There is one cell that is slightly placed in wrong location (e.g., error is between 15% and 30% of the nominal cell size). There are five cells that have severe placement error (e.g., beyond 30%).

To view which cells are in the wrong place, left click on the Center Offset field in the DMx Data window to switch to the graphic display of the Center Offset in the main window. To display only the cells having placement errors greater than 15%, uncheck the option Offset < 15% in the Center Offset dialog box. (You can display the dialog box by left double clicking on the Center Offset field in the DMx window or selecting Set>Center Offset). The single cell having moderate error is marked in yellow and the five cells having severe placement errors are marked in red.

FIGURE 3–9. Data Matrix with Center Offset Problem



Similarly, the Size Offset of 2.4 indicates a minor size offset problem. There are two cells whose area are significantly different (larger or smaller) than the average cell area. You can easily identify them by checking the display option Offset > 30% in the Size Offset dialog box.

FIGURE 3–10. Data Matrix with Size Offset Problem

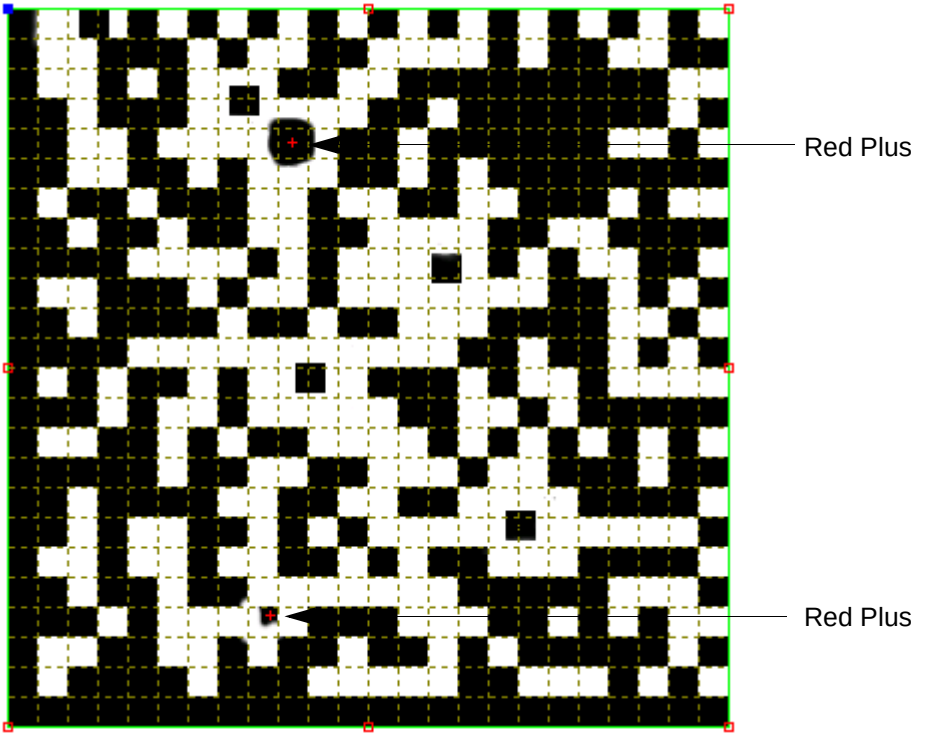


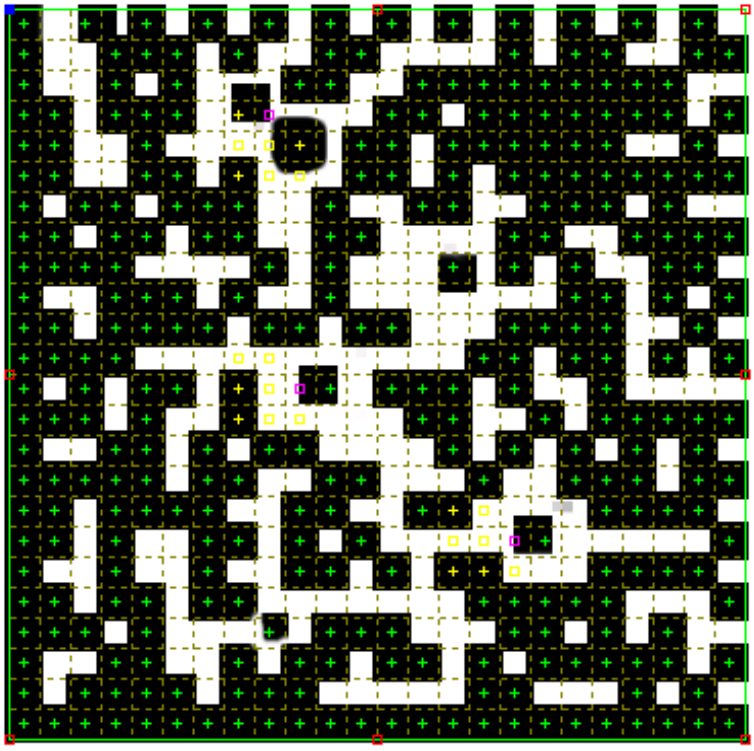
TABLE 3–1. Mouse Action in DMx Data Window

Action	Field	Result
Left Click	Center Offset	Displays cells having various Center Offset errors
	Size Offset	Displays cells having various Size Offset errors
	Error Correction	Displays wrong cells and code words
Left Double Click	Center Offset Size Offset Error Correction	Displays the options that allow you to choose what is to be displayed in the main window

Sample 3 — Overprinted Data Matrix

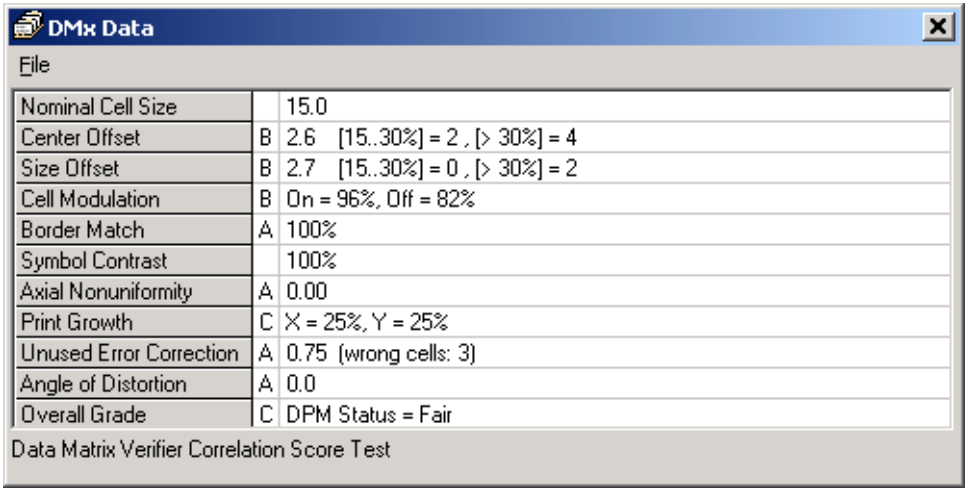
The Data Matrix in sample3.bmp has overprinted cells in addition to the problems presented in sample2.bmp. The positive Print Growth values reflect this problem.

FIGURE 3–11. Data Matrix Image — Overprinted Cells



The measurement results are:

FIGURE 3–12. Data Matrix Image — Measurement Results

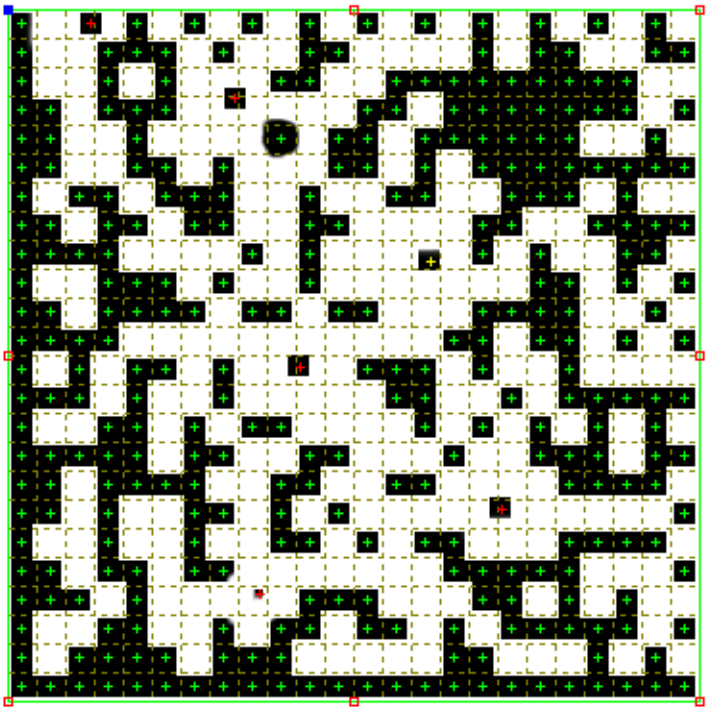

DMx Data
File
Nominal Cell Size 15.0
Center Offset B 2.6 [15..30%] = 2 , [> 30%] = 4
Size Offset B 2.7 [15..30%] = 0 , [> 30%] = 2
Cell Modulation B On = 96%, Off = 82%
Border Match A 100%
Symbol Contrast 100%
Axial Nonuniformity A 0.00
Print Growth C X = 25%, Y = 25%
Unused Error Correction A 0.75 (wrong cells: 3)
Angle of Distortion A 0.0
Overall Grade C DPM Status = Fair
Data Matrix Verifier Correlation Score Test

The Center Offset and Size Offset remain virtually unchanged but Print Growth has worsened to 25% in both horizontal and vertical directions. This means the width and height of On cells are on average 25% greater than Nominal Cell Size.

Sample 4 — Underprinted Data Matrix

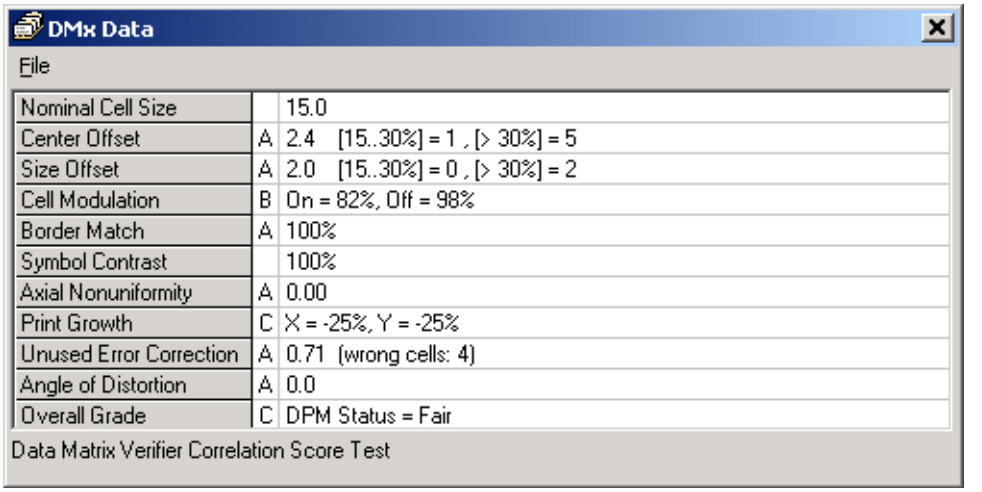
The Data Matrix in sample4.bmp is severely underprinted and has negative print growth values. Figure 3–13 displays the main window with center offset error.

FIGURE 3–13. Data Matrix Image — Center Offset Error



The DMx window shows the measurement results, as shown in Figure 3–14.

FIGURE 3–14. Data Matrix Image — Underprinted Label


DMx Data
File
Nominal Cell Size 15.0
Center Offset A 2.4 [15..30%] = 1 , [> 30%] = 5
Size Offset A 2.0 [15..30%] = 0 , [> 30%] = 2
Cell Modulation B On = 82%, Off = 98%
Border Match A 100%
Symbol Contrast 100%
Axial Nonuniformity A 0.00
Print Growth C X = -25%, Y = -25%
Unused Error Correction A 0.71 (wrong cells: 4)
Angle of Distortion A 0.0
Overall Grade C DPM Status = Fair
Data Matrix Verifier Correlation Score Test

The Center Offset and Size Offset have changed little from sample2, but the Print Growth is very poor at -25% in both the horizontal and vertical directions.

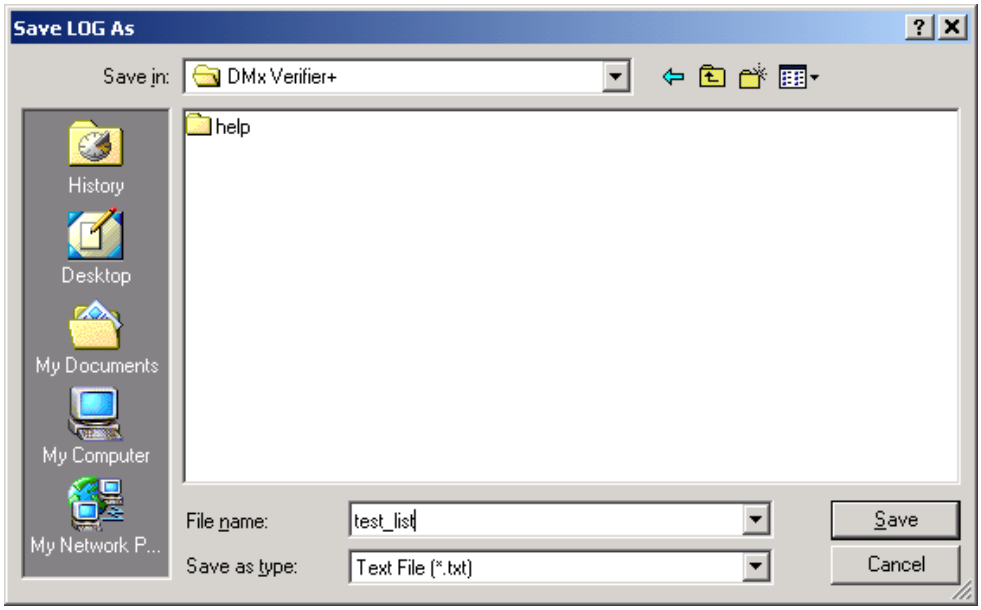
Auto Check in List Mode

You can use List Mode to verify multiple Data Matrix images and save the results to a file:

1. Ensure Log is checked in Set > Log Data.
2. Select File > Open List to display the Open List dialog box.
3. Select (to highlight) the file names to be opened.
4. To load the images, click Open.
5. Select Tools > Auto Check to display the Check List in AUTO mode message box.
   - Click Yes if you do not wish to examine the graphic display of the verification results. The DMx Verifier+ will step through the image files in the list automatically.
   - Click No to examine the graphic display before pressing Space bar to get to the next image.

6. Enter the name for the log file and select the Save button.

FIGURE 3–15. Save Log As Dialog Box



7. Enter comments to be included in the log file if desired, and select OK.

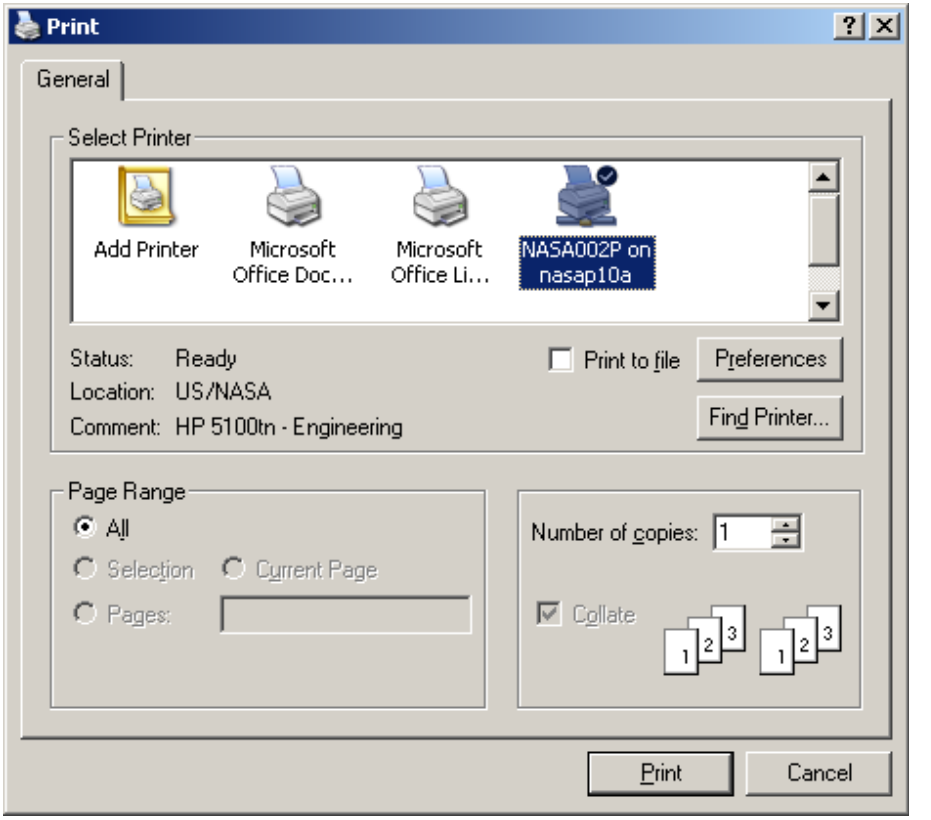
8. All images in the list are verified one by one and results saved into two log file TEST_LIST.TXT and TEST_LIST.PRN.

Verification Results Reporting

Printing the Verification Results Only

1. From the DMx Data window, select File > Print to print the data only. The Print window will be displayed, as shown in Figure 3–16.

FIGURE 3–16. Print Window



2. Select Print to display the DMx Comments window. From here, you can enter some comments that will also appear on the printed page. You can describe the physical Data Matrix sample, how the image was captured, etc.

FIGURE 3–17. Data Matrix Comments Window

3. Enter some comments that will also appear on the printed page. You can describe the physical Data Matrix mark, how the image was captured, etc.

4. Select OK to print the results. The verification results also include the data displayed in the DMx Properties window.

Printing the Data to a File

1. To display the Print window, follow the instructions in "Printing the Verification Results Only" on page 3-16.

2. Inside the Printer group, enable the Print to File option, and then select OK.

The Save Log As box will be displayed, which allows you to enter the file name for storing the data. If the file already exists, the data will be appended to the end of the file.

Printing the Image with Verification Results

In the main application window, select File > Print to print the image and the verification data.

Printing the Image Only

After opening a new image, and before performing Auto Check, select File > Print to print the image.

4

CHAPTER 4

DMx Verifier+ Reference Guide

This chapter provides a complete reference guide for DMx Verifier+ operation. It explains the menu selections, toolbar buttons, dialog boxes, and image windows provided in this product.

Verifier Menu Descriptions

This section describes the following menus:

- "File Menu" starting on page 4-2
- "Set Menu" starting on page 4-5
- "View Menu" starting on page 4-15
- "Pre Process Menu" starting on page 4-18
- "Tools Menu" starting on page 4-19
- "Help Menu" starting on page 4-27

File Menu

FIGURE 4–1. File Menu

File>Open

This menu item opens a BMP image, TIFF image, or a RAW image of size 640x480 or 320x240. Although a 24-bit image can be opened and displayed, the Auto Check menu is enabled only for 8-bit (256 grayscale values) images.

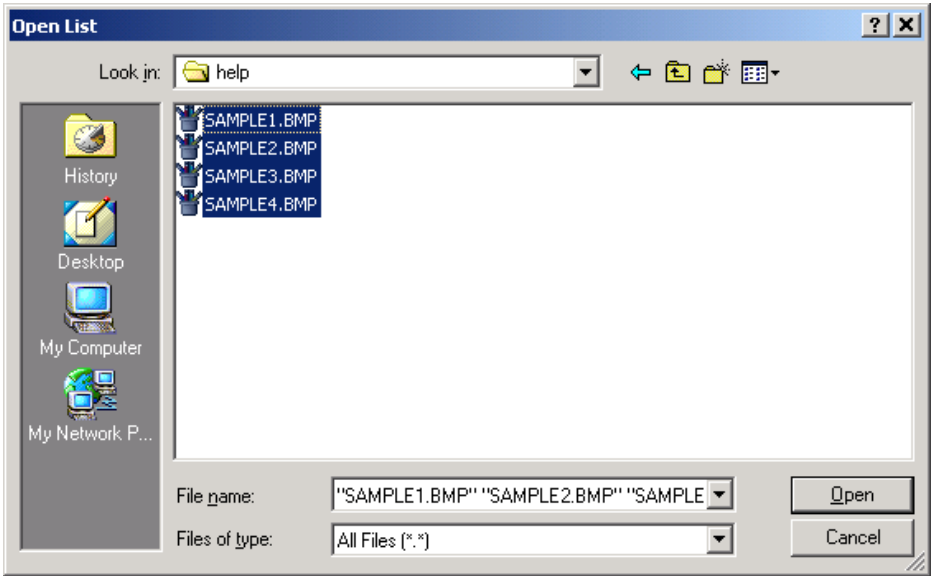
File>Open List

This menu item opens a list of image files in the same directory. This is convenient when you need to perform verification on a list of images without having to manually open each image and then select Auto Check. Furthermore, you have the option to create two log files (.txt and .prn) and save the results to them. The file .prn can be opened with Microsoft Excel program for further data processing. You also have the option to run Auto Check for each image in the list automatically or manually.

- If Auto mode is **selected**, all images in the list will be processed one after another with no pause between images.
- If Auto mode is **not selected**, the DMx Verifier+ will pause to let you examine the verification results of the current image and allow to you to get to the next image in the list by pressing the Space bar on the keyboard.

Note: You can hold down the Ctrl or Shift key and left click the mouse button to select a file to be added into the file list.

FIGURE 4–2. Open List Dialog Box



File>MXi

If an MXi Hand-Held Reader is connected to serial port COM1 or COM2 of the PC, selecting this menu item will allow the image captured in the MXi image buffer to be downloaded to the program and displayed.

File>Grab

This menu item is enabled only when the 0300 board is installed in the PC. Selecting File>Grab triggers the 0300 board to capture and display an image.

File>Live

This menu item is enabled only when the 0300 board is installed. Selecting the menu allows live images to be displayed.

File>Save As

This menu item saves the image currently displayed in the main window as a BMP file.

File>Print

This menu item prints the image. The measurement results will also be printed if Auto Check is successful.

File>Job

- Load>Default — Reset all configuration parameters to factory default settings.
- Load>Job — Load a previously saved job that contains all configuration parameters. This is useful for restoring previously configured parameters. To view the loaded job name, select File>Jobs again.
- Save — Save the current configuration parameters to a job file in the disk.
- Delete — Delete a job file from the disk.

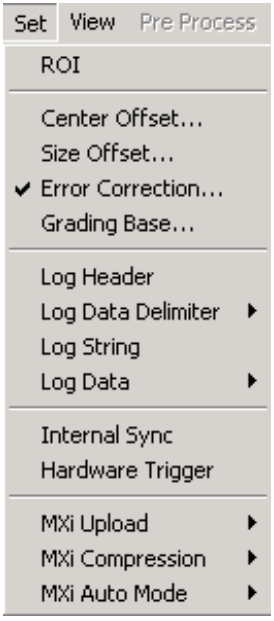
Note: We recommend (although not required) that all jobs be stored in the `\DMx Verifier+\jobs` directory, which is normally under `C:\Program Files`.

File>Exit

This menu item exits the program.

Set Menu

FIGURE 4–3. Set Menu

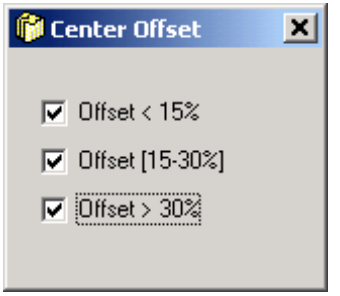


Set>ROI

By default, the Region of Interest (ROI) is the full image. You can set the ROI by selecting this menu item and then pressing and holding down the left mouse button and dragging the pointer across the desired area. The ROI can specify the Data Matrix to verify when there is more than one Data Matrix in the image.

Set>Center Offset

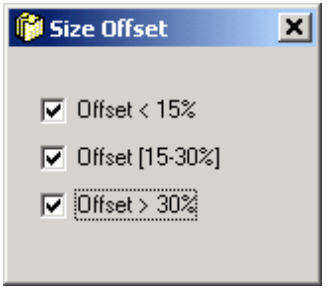
FIGURE 4–4. Center Offset Dialog Box



This menu item is enabled when DPM or IAQG is chosen in the Grading Base dialog box and an ECC200 Data Matrix is successfully verified. For DPM, you have the option to highlight the Data Matrix cells that have cell placement error less than 15%, between 15% and 30%, and/or greater than 30%, of the nominal cell size, respectively. For IAQG, the corresponding ranges are less than 10%, between 10% and 20%, and greater than 20%, respectively.

Set>Size Offset

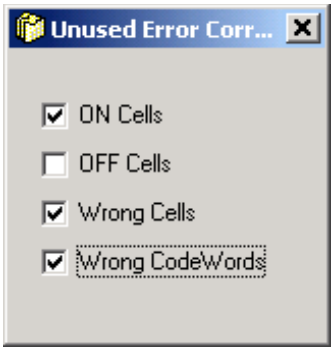
FIGURE 4–5. Size Offset Dialog Box



This menu item is enabled when DPM or IAQG is chosen in the Grading Base dialog box and an ECC200 Data Matrix is successfully verified. For DPM, you have the option to highlight the cells of an ECC200 Data Matrix that have variation error less than 15%, between 15% and 30%, and/or greater than 30%, of the average cell area, respectively. For IAQG, the corresponding ranges are: less than 10%, between 10% and 20%, and greater than 20%, respectively.

Set>Error Correction

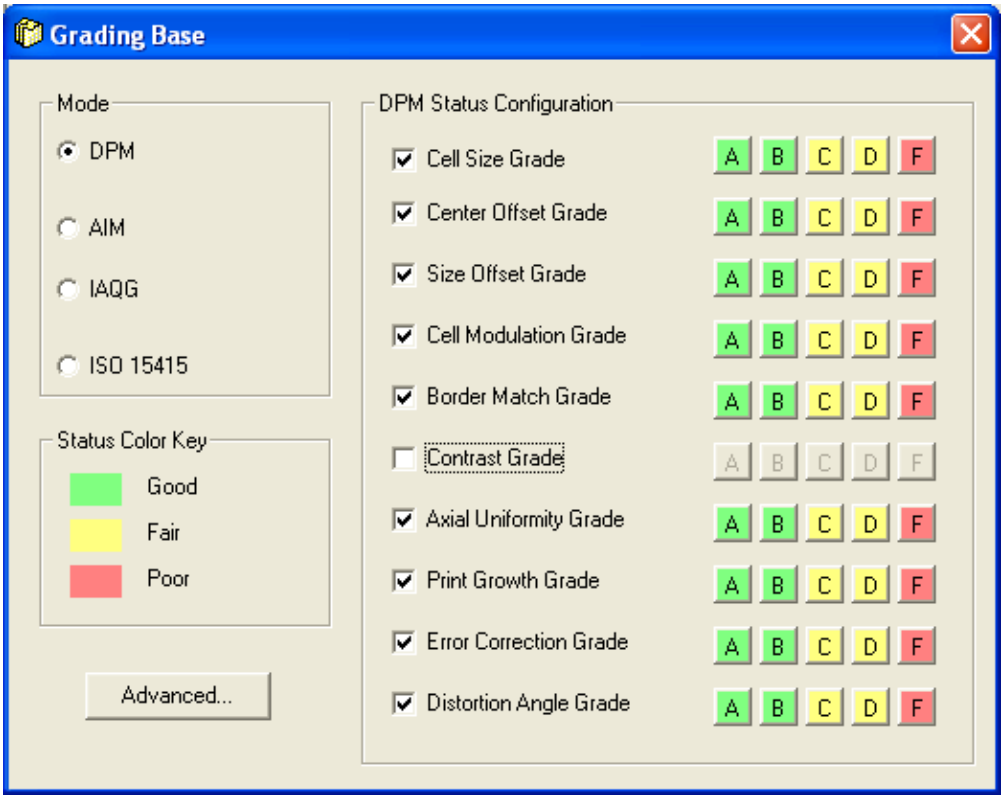
FIGURE 4–6. Error Correction Dialog Box



This menu item is enabled when DPM is chosen in the Grading Base dialog box and an ECC200 Data Matrix is successfully verified. You have the options to highlight On cells, Off cells, Wrong cells (if any), and the corresponding wrong code words.

Set>Grading Base

FIGURE 4–7. Grading Base Dialog Box



Use the dialog box to set the verification method to DPM, AIM, IAQG, or ISO 15415. When DPM is selected and Print Growth Grade is checked in DPM Status Configuration, clicking Advanced button will display a new dialog for you to enter new Ideal (or Target) Print Growth (TGP). For more information on TGP, see “Print Growth (PG)” on page 2-14.

When ISO 15415 is selected, clicking Advanced button will display a new dialog for you to enter Aperture Size. The default Aperture Size of 0 means a synthesized aperture of 0.8 times the X dimension is used as the measuring aperture specified in the ISO 15415 document. Other values from 4 to 20 can be entered if it is specified by the user application specification. For example, you can enter 5 for MIL-STD-130 which specifies 05 to be used. Whenever a non-

zero value is to be used, the system must be calibrated first using Contrast/Size Calibration.

The Verification Status is user configurable and determined by the parameter grade or the overall grade. The verification status has the values Good, Fair, Poor and is displayed in the DMx Window along with Overall Grade. For AIM, ISO 15415, and IAQG, the verification status is determined by the overall grade based on Status Configuration for the selected verification method. By default, the verification status is Good for the overall grade of A or B, Fair for C or D, and Poor for F. Figure 4–8 shows the default status configuration for the IAQG method.

FIGURE 4–8. Default Status Configuration for IAQG

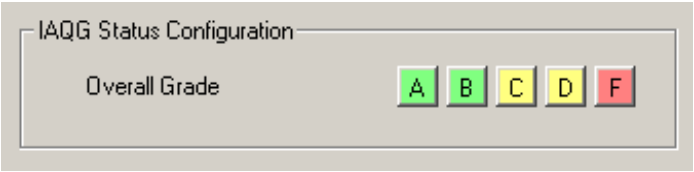


Figure 4–9 shows the status configuration for ISO 15415 such that the grades A, B, and C correspond to Good, D corresponds to Fair, and F corresponds to Poor.

FIGURE 4–9. Status Configuration for ISO 15415

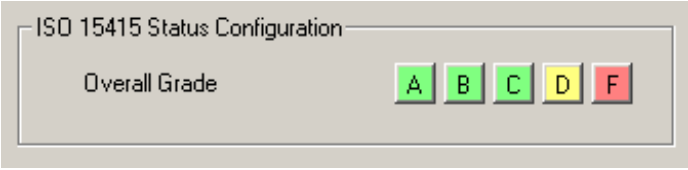
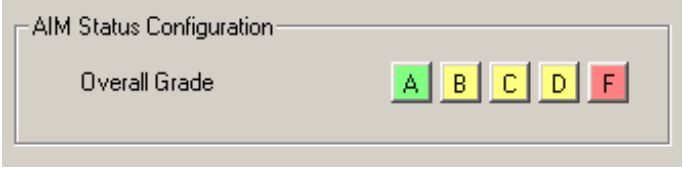


Figure 4–10 shows the status configuration for AIM such that the grade A corresponds to Good, the grades B, C, and D correspond to Fair, and F corresponds to Poor.

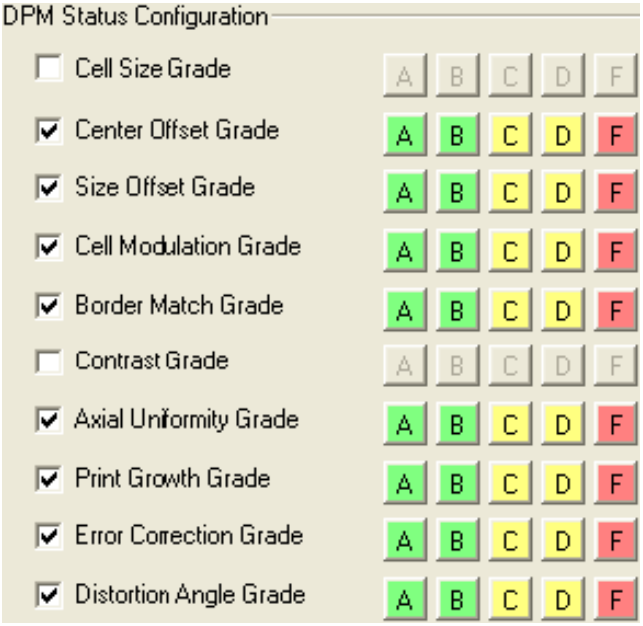
FIGURE 4–10. Status Configuration for AIM



For DPM, the verification status is determined by the parameter status of all enabled parameters. For each parameter, the parameter status is determined by the grade of the parameter and the status configuration for the parameter. The verification status is the lowest parameter status of all enabled parameters.

Figure 4–11 shows the status configuration for DPM with tighter constraint on the Border Match quality. For the DPM verification status to be Good, Border Match Grade must be A and the rest of the enabled parameters must be A or B. For the verification status to be Fair, Border Match Grade must be B and the rest of the enabled parameters must be C or D. If Border Match has the grade C or D, then the verification status will be Poor.

FIGURE 4–11. Status Configuration for DPM



Set>Log Header

When you use Open List to open a list of images for verification (if Set > Log Data > Log is checked), two log files (.txt and .prn) will be created to save the verification results. Both files contain the full verification results arranged in different format. The .txt file displays the results the same way as they appear in the DMx Window result box when Auto Check is performed. The .prn file

tabulates the results that can be easily processed by other programs such as Microsoft Excel.

- If Log Header is **checked**, the header is displayed in the .prn file. The header contains the name or title for each parameter field. This is the default.
- If the Log Header is **unchecked**, no header will be shown in the .prn file.

Set>Log Data Delimiter

The default Log Data Delimiter in the .prn file is Tab. You can change the delimiter to Comma, Semi Colon, Space, or Tilde.

Set>Log String

When Log String is checked, the Data Matrix decoded data will be added at the end of each record of the verification results in the .prn file. By default, the decoded data is not included in the .prn file.

Set>Log Data

Set>Log Data>Log

- When Log is **checked**, two log files .txt and .prn will be created in the application directory when a list of Data Matrix images are verified using the Open List menu
- When Log is **unchecked**, verifications data will not be saved to the log files when Open List is used for analyzing a list of Data Matrix images.

Set>Log Data>Delete

If no log files .txt and .prn have been created, this menu item is grayed out. Once the log files are created, the menu becomes enabled. Selecting Delete will delete the two log files. Once the log files are deleted, the menu is grayed out again.

Set>Internal Sync

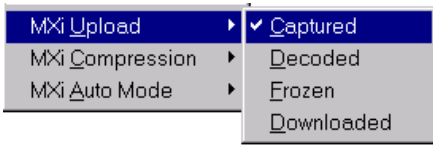
You need to check this if you use the Internal Sync MVi camera from NER.

Set>Hardware Trigger

To use the Opto I/O board to trigger the 0300 board to acquire an image, you need to check the Hardware Trigger option, then select File>Grab. When a trigger occurs, an image will be acquired for you to perform Auto Check.

Set>MXi Upload

FIGURE 4–12. MXi Upload



This menu item is visible when MXi is connected to the PC's serial port. MXi Upload allows an image stored in the MXi to be uploaded to the Verifier to be displayed. MXi has four buffers for storing images (consult the MXi User Manual for complete details):

- Captured — When this option is checked, the image captured by MXi in full resolution (640x480) is uploaded from the MXi to the Verifier when you select File>MXi.
- Decoded — When this option is checked, if the Data Matrix is decoded by the MXi, then only a small portion of the image containing the Data Matrix area is uploaded to the Verifier. If no Data Matrix is decoded, then the full image (640x480) is uploaded.
- Frozen — When this option is checked, the image captured to the Frozen buffer is uploaded to the Verifier.

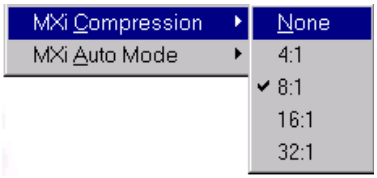
Note: The MXi can be set to transfer the captured image to the Frozen buffer with FREEZE command.

- Downloaded — When this option is checked, the image in the MXi Downloaded buffer is uploaded to the Verifier.

Note: The MXi Downloaded buffer is used for storing the image that is downloaded to MXi from an image file.

Set>MXi Compression

FIGURE 4–13. MXi Compression

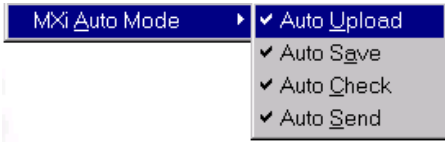


This menu item is visible when MXi is connected to the PC's serial port. When MXi Compression is set to None, the image captured by MXi is uploaded to the Verifier without being compressed. When other compression ratios are selected, the MXi compresses the image and upload it to the Verifier using less time.

The default compression ratio is 8:1. The higher the compression ratio, the faster the uploading process and the poorer the image displayed in the Verifier. For the Verifier to produce consistent verification results, we do not recommend that you use compression ratios higher than 8:1. You can use 16:1 or 32:1 if you want to quickly view the image captured by the MXi.

Set>MXi Auto Mode

FIGURE 4–14. MXi Auto Mode



This menu item is visible when MXi is connected to the PC's serial port. By default, MXi Auto Mode is disabled.

- Auto Upload — If this option is checked, whenever MXi decodes a Data Matrix (by pressing the button), the Data Matrix image is automatically uploaded from the MXi Captured buffer to the Verifier to be displayed.

- Auto Save —

Auto Save	Auto Upload	What It Means...
Checked	Checked	Whenever MXi decodes a Data Matrix, the Data Matrix image is automatically uploaded in the Verifier and automatically saved to the PC's hard drive.
Checked	Unchecked	Whenever you select File>MXi to upload the image from the MXi to the Verifier, the image is displayed and saved automatically.

When you enable the Auto Save mode by checking it, Verifier displays the Save As dialog box for you to enter the file name. This file name is used by the Verifier in generating the subsequent file names for uploaded images by appending two digits to the filename you entered. The two digits start from 00 and end with 99. For example, if you enter file name as "my test", Verifier will save the images as "my test00.bmp", "my test01.bmp", and so on. When the last two digits reach 99 after saving 100 files, you need to move the image files so that they will not be replaced with newly uploaded image files.

- Auto Check — This option is grayed out if Auto Upload is unchecked. When Auto Upload is checked, you can further check Auto Check so the Verifier will perform the Auto Check operation upon receiving the uploaded image. If the Auto Check operation is successful, the results will be displayed in the DMx Data window when Auto Send option is not checked.

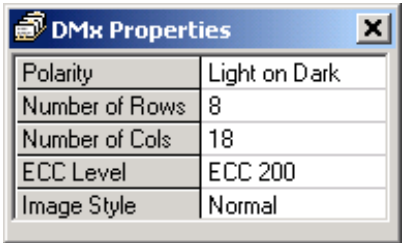
- Auto Send — This option is available only when both Auto Upload and Auto Check are checked. By checking Auto Send, the results from Auto Check will be sent as if they were entered from the PC's keyboard. This can allow the verification results to be sent directly to a Windows program, such as Microsoft Excel, that has the window focus.

View Menu

FIGURE 4–15. View Menu

View>DMx Property

FIGURE 4–16. DMx Properties



Once Auto Check is successfully performed, use this menu item to display the Data Matrix properties shown in Figure 4–16.

View>DMx Data

After Auto Check is successfully performed, use this menu item to display the DMx Data window that contains all Data Matrix verification results.

View>Threshold Display

This menu item displays the thresholded image. This is strictly a viewing tool that does not alter the original image. Therefore, it does not affect the Data Matrix verification results.

View>Contrast Display

This menu item displays the contrast enhanced image. This is strictly a viewing tool that does not alter the original image. Therefore, it does not affect the Data Matrix verification results.

View>Zoom In

When verification is performed successfully on a small Data Matrix, this menu may become enabled. In this case, you can use this menu to enlarge the Data Matrix graphical display and view more details. You can even use the Set ROI button to clear the graphics and re-enable Auto Check button. Pressing the Auto Check button to perform the verification on the enlarged image usually gives you more accurate verification results.

View>Undo Zoom

This menu item restores the image to the original size before Zoom In was used.

View>Solid Grid

Select this menu item to change the appearance of the grid lines in the graphic display of the Data Matrix verification.

View>Lite Grid

Select this menu item to change the appearance of the grid lines in the graphic display of the Data Matrix verification.

View>Camera

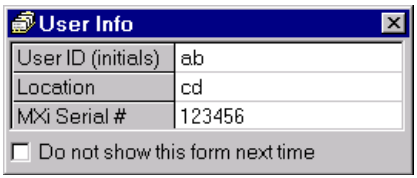
The 0300 board supports up to four cameras. You can select one of the cameras that is connected to the board for image acquisition.

View>MXi String

This menu item displays the data sent from the MXi, and is visible after MXi has sent some data to the Verifier when its trigger is pushed.

View>MXi ID Form

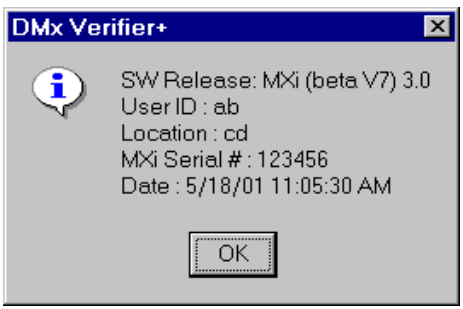
FIGURE 4–17. User Info Dialog Box



This menu item displays the MXi ID Form, and is visible when MXi is connected to the PC. The same ID Form is usually displayed when you launch the Verifier while MXi is connected to the PC.

View>MXi Header

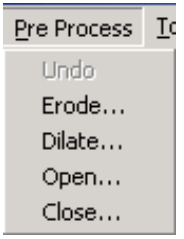
FIGURE 4–18. MXi Header Window



This menu item displays MXi information, and is visible when MXi is connected to the PC.

Pre Process Menu

FIGURE 4–19. Pre Process Menu



When the Data Matrix quality is too poor for the verification to be successful, use the Pre Process Menu to enhance the image quality. Proper preprocessing steps may enhance the image such that the measurement results can be obtained. Although the results only represent the quality of the Data Matrix mark with image enhancement, they can still provide useful information to help identify various mark quality problems.

Pre Process>Undo

Use this menu item to undo any preprocessing step(s) and restore the original image.

Pre Process>Erode

Use this menu item to erode light pixels to increase the size of dark cells and reduce the size of light cells in a Data Matrix image. Use this when On cells are too small in a dark on light image or too large in a light on dark image.

Pre Process>Dilate

Use this menu item to dilate light pixels to reduce the size of dark cells and increase the size of light cells in a Data Matrix image. Use this when On cells are too large in a dark on light image or too small in a light on dark image.

Pre Process>Open

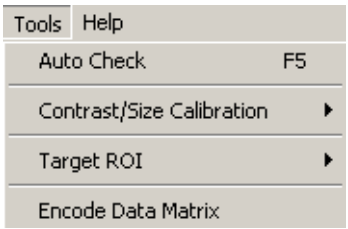
This is equivalent to Erode followed by Dilate. Use this to remove small light colored defects in a Data Matrix image.

Pre Process>Close

This is equivalent to Dilate followed by Erode. Use this to remove small dark colored defects in a Data Matrix image.

Tools Menu

FIGURE 4–20. Tools Menu

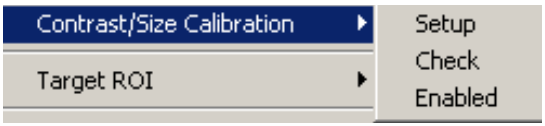


Tools>Auto Check

This menu item performs Data Matrix verification calculations based on the verification mode configured in the Set > Grading Base dialog box. If the verification is successful, the verification results will be displayed in the DMx Data window with additional Data Matrix properties available for display in the DMx Property window. If the verification is not successful, the message “No Measurement Possible” will be displayed in the status panel.

Tools>Contrast/Size Calibration

FIGURE 4–21. Contrast/Size Calibration



The DMx Verifier+ system must be calibrated in order to report the cell/module size in mil (1/1000th of an inch) and the contrast as a NIST traceable value.

The Setup menu allows you to calibrate the camera system using the Microscan Calibration Test Card. Once the system is calibrated, you should not change the camera’s FOV, focus, aperture, or lighting. The Check menu allows you to determine if the current calibrated setup needs to be re-calibrated. The menu Enabled should be displayed for reporting the calibrated values, however you have the option to report the non-calibrated values as well by clicking Enabled to change it to Disabled. If the calibration is disabled, the contrast value reported depends on and varies with the lighting and the cell size is reported in pixels rounded to one decimal place. If the calibration is enabled, the contrast value reported is based on NIST traceable density scale and will not vary with lighting

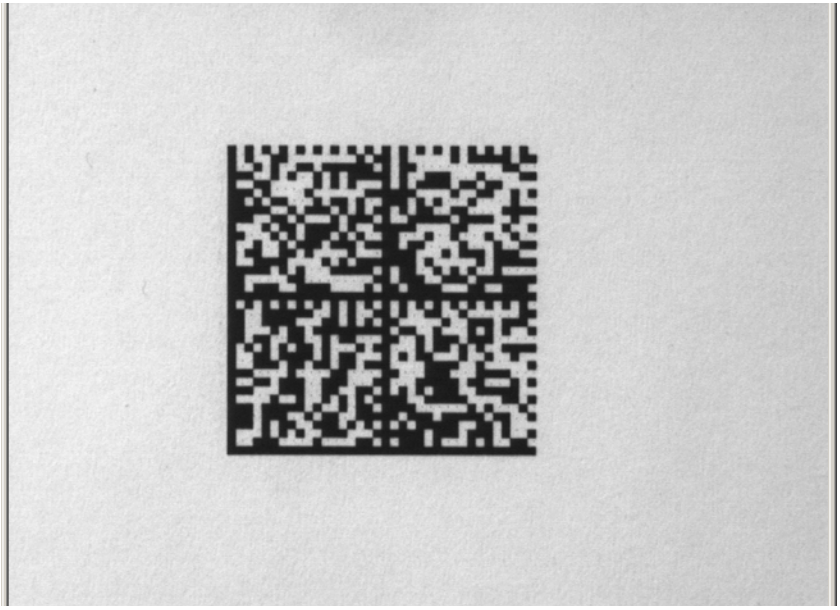
and the cell size is reported in mil (1000th of an inch) rounded to the nearest integer.

Before performing calibration, you should have already determined the correct FOV of your camera setup and lighting based on the size and the surface/marking reflectivity of the Data Matrix in your application. Then, you select File>Live to display live images of one of the Data Matrix targets on the Microscan Calibration Test Card. Choose the target that is about 1/3 to 1/2 of the FOV size. It is important that the same target be used in both the Setup process and the Check process.

Calibration Setup

1. Select File > Live. Place a Data Matrix target of suitable size near the center of the FOV. If necessary, adjust the lighting, the camera's f-stop (aperture), or focus to obtain good images. The images should not look too dark or saturated (i.e., the value of light pixels should not reach 255). Select File > Live to exit the live video mode and capture an image.

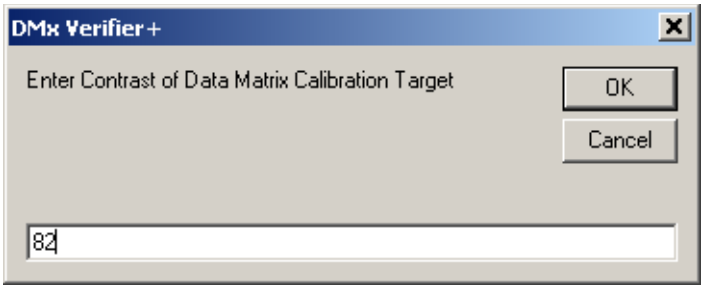
FIGURE 4–22. Black and White Data Matix Label — Step 1



2. Select Tool > Contrast/Size Calibration, and then select Setup.

   The Enter Contrast of Data Matrix Calibration Target dialog box is displayed, as shown in Figure 4–23.

FIGURE 4–23. Enter Contrast of Data Matrix Calibration Target Dialog Box



3. Enter the contrast of the target shown on the Microscan Calibration Test Card. Press OK.

   If the calibration is successful, the following message will be displayed in the Status bar:

   Calibration succeeded and enabled

   You can verify that Calibration Mode is now enabled by selecting Tools > Contrast/Size Calibration to see that Enabled is displayed. If the calibration is unsuccessful, then one of the following messages will be displayed instead:

   – Calibration failed. No Data Matrix found

   – Calibration failed. Invalid calibration target

   – Calibration failed. Adjust image

Calibration Check

For a calibrated system, you can check to see if it has changed from the last calibrated state such that it may require re-calibration. To do this, place (in the center of the FOV) the same target that was used in the calibration setup process. Then, select Tools > Calibration > Check. If no re-calibration is necessary, you will get this message:

Calibration OK. No need to re-calibrate

Otherwise, you may get one of the following messages if an incorrect target was used, or the light intensity or FOV has changed:

- Please use original calibration target
- Image too dark. Please re-calibrate
- Image too bright. Please calibrate
- Cell Size too small. Please calibrate
- Cell Size too large. Please calibrate
- Failed to decode. Please adjust image

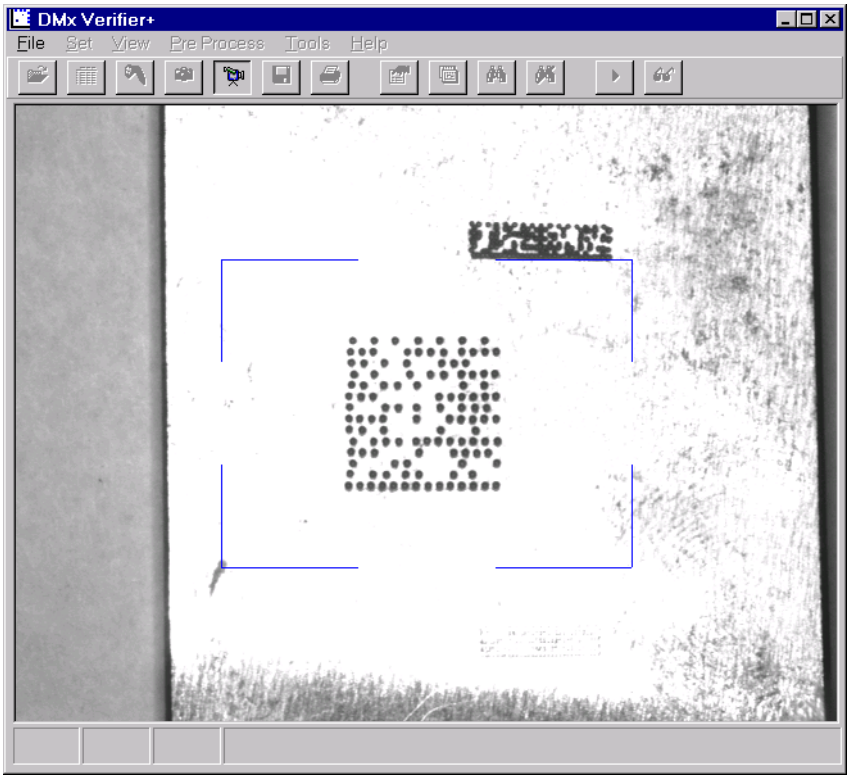
Tools>Target ROI

FIGURE 4–24. Target ROI Menu Item

This menu item allows you to set up a target ROI window (i.e., view finder) to be displayed with live images. Uniform lighting is necessary for obtaining accurate and repeatable measurement results. The use of the target ROI helps the operator place the Data Matrix marks of the same size in the center area where the lighting is more uniform. The following are the steps for setting up the target ROI:

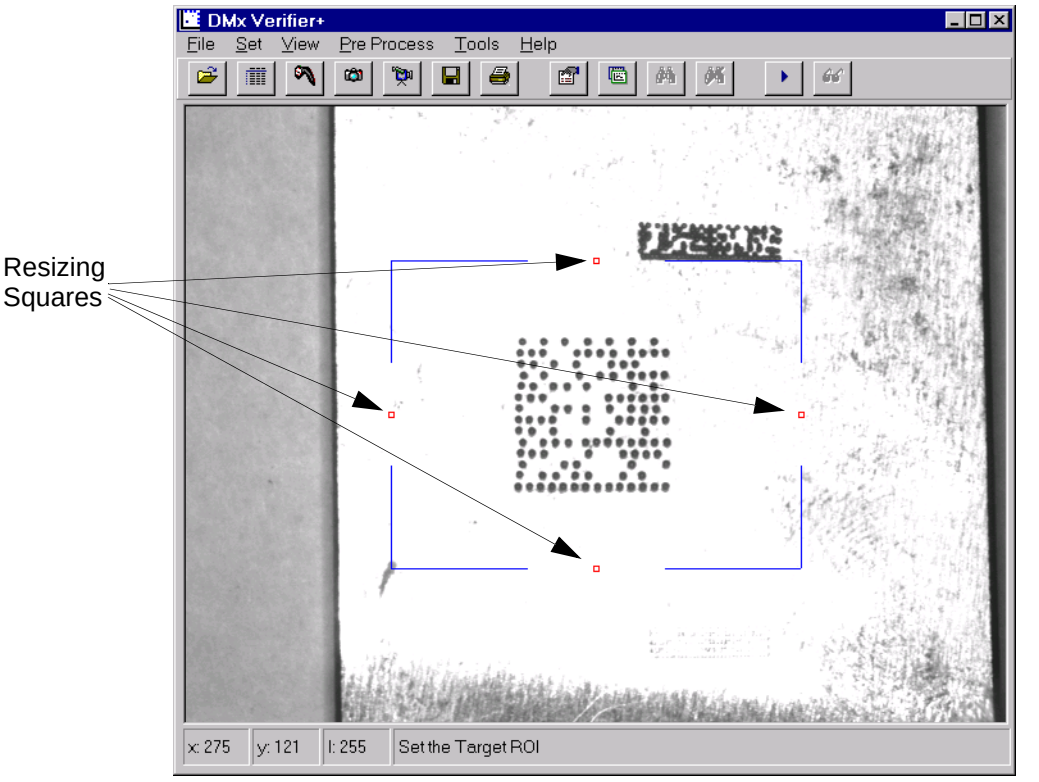
1. Select Tools > Target ROI > Disabled once so it becomes Enabled. Click Live to display the target ROI in live image mode. Place the Data Matrix mark to be measured in the center of the target ROI, as shown in Figure 4–25.

FIGURE 4–25. Data Matrix in Center of Target ROI



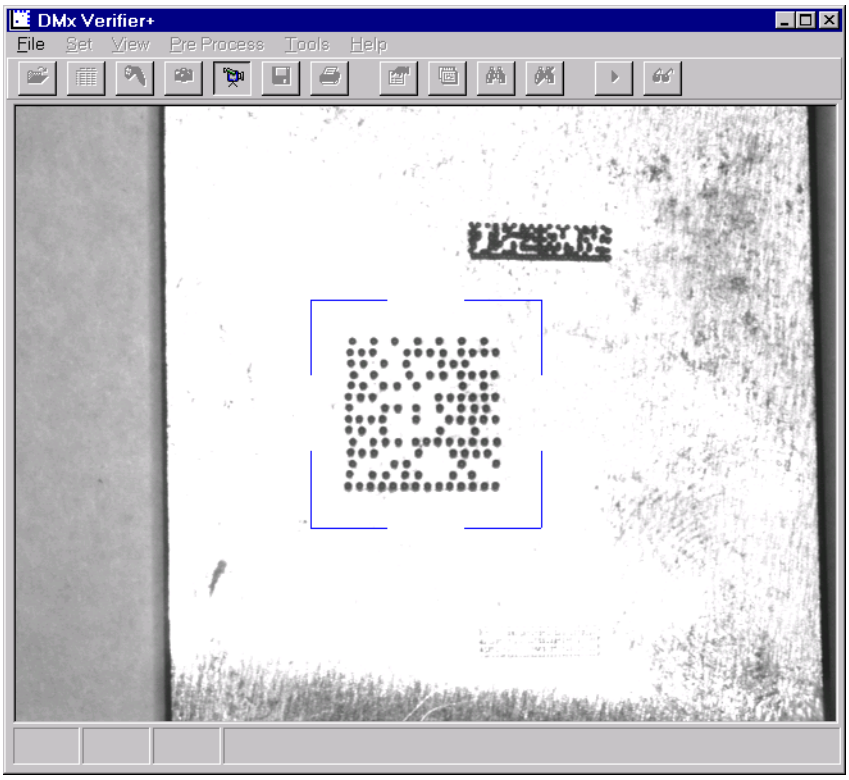
2. Click on the recessed Live button again to stop the live image display. Select Tools > Target ROI > Setup to display the screen shown in Figure 4–26.

FIGURE 4–26. Data Matrix with Resizing Squares Displayed



3. Left click and drag the small red squares to resize the target ROI to the desired size. This target ROI will be displayed in the live image view unless you disable it by selecting Tools > Target ROI > Enabled to change it to Disabled.

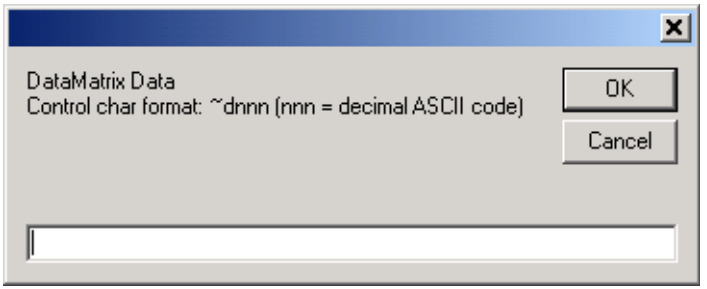
FIGURE 4–27. Data Matrix with Target ROI Resized



Tools>Encode Data Matrix

This menu item displays the dialog box in Figure 4–28. It allows you to enter the data to be encoded into a square Data Matrix. (Rectangular Data Matrix will be available later.)

FIGURE 4–28. Encode Data Matrix



To enter a character that is shown on the keyboard, simply type it in. Or, you can enter the same character using the format:

~dnnn

Where:

nnn is the decimal ASCII value of the character

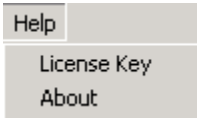
For example, to encode the string Ab1#, you can key in either Ab1# or ~d065~d098~d049~d035. The format ~dnnn is needed for entering ASCII characters that cannot be easily typed in from the keyboard.

Once you select OK after entering some data, a new dialog box is displayed for you to enter the number of columns (and rows) of the Data Matrix. If you prefer to have the encoding algorithm generate the smallest Data Matrix for you, simply accept the default value of 0 and select OK. You will be asked for Cell Width (e.g. Grid size) and Dot Size, both in pixel units (both default to 5).

You can also force the Data Matrix to a certain size by entering the number of columns (and rows) yourself. The value must be large enough to accommodate the data to be encoded. Otherwise, the message “Not Valid Data” will be displayed.

Help Menu

FIGURE 4–29. Help Menu



Help>License Key

The software would not run without a License Key attached to the parallel or USB port of the PC.

Help>About

This menu item displays the software version.

A

APPENDIX A Data Matrix Symbology

This appendix describes the Data Matrix Symbology.

Data Matrix Certification

Data Matrix has been certified by AIM-USA and AIM-International as a fully public-domain symbology. AIM stands for Automatic Identification Manufacturers International, Inc. It is located on the Internet at **http://www.aimi.org/bib4.htm**, which provides the complete specification.

Data Matrix has also been selected as a standard for 2D marking by a majority of industry organizations such as SEMI Standard T2, Electronics Industries Association (EIA), and Automotive Industry Action Group (AIAG).

What Is Data Matrix?

The Data Matrix is a unique machine-readable symbol capable of storing a large amount of information within a small physical size. Examples are shown in Figure A–1.

FIGURE A–1. Data Matrix Examples

The Data Matrix symbology allows for two-dimensional encoding and decoding. For the first time, users are no longer constrained by the limitations of a printed symbol. Now, with the Data Matrix symbology, users have the ability to:

- Select output size ranging from .001 square inches to 14 square inches, regardless of the amount of data encoded.
- Encode up to 3116 numeric characters or 2335 alphanumeric characters in a single symbol.
- Encode and read many supported international languages.
- Easily integrate with existing computer systems.

Data Matrix symbols are capable of carrying 25 to 100 times more information than the typical barcode. This range is directed related to the image quality that the printer is capable of producing.

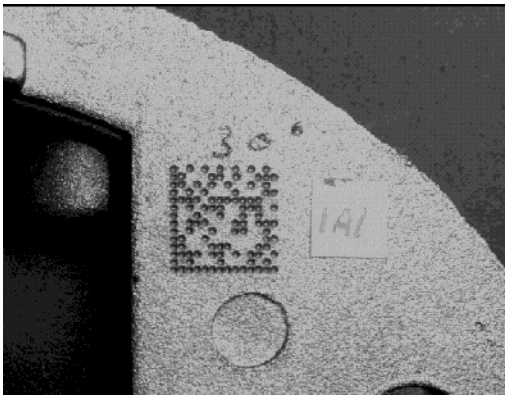
The following summarizes the characteristics of 2D Data Matrix:

- Both height & width encode data.
- Works with contrast as low as 20%.
- Readable through 360^{o} of rotation.
- Designed to survive harsh industrial environments.
- Codes can be marked on the surface of a part, without using a paper label.
- Every DM code is half black and half white to help ensure that cell damage will not harm readability.
- Several error correction schemes are available to optimize symbol damage recovery.

- Advanced image processing is used for higher read rates of cluttered and/or damaged symbols.

Figure A–2 illustrates a Data Matrix on an actual part.

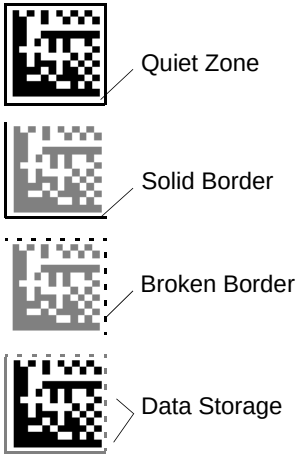
FIGURE A–2. Data Matrix Example



Data Matrix Components

Data Matrix consists of a solid border, a broken border, a data storage area, and a quiet zone, as depicted in Figure A–3.

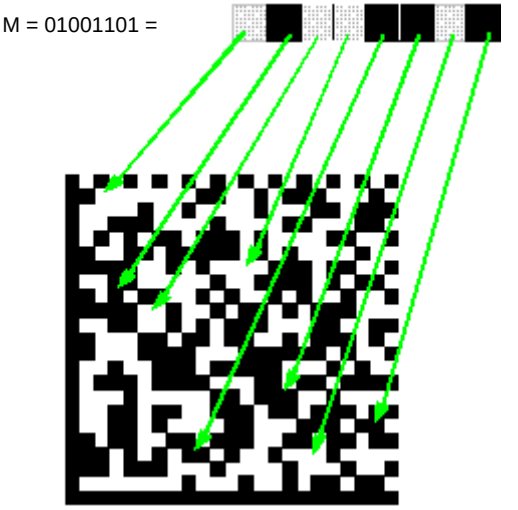
FIGURE A–3. Data Matrix Components



The DMx Verifier+ uses the solid border to calculate the rotation of a Data Matrix symbol. The DMx Verifier+ uses the broken border to identify the number of rows and columns in a symbol. The data storage area contains the binary information that was encoded during the construction of the Data Matrix.

The data storage area is illustrated in Figure A–4, showing how data is stored in 8-bit format. Each encoded data character can be represented by an 8-bit binary code. The character *M*, for example, is *01001101*. 1=dark cell, 0=light cell. *M* is stored in the Data Matrix as shown.

FIGURE A–4. Data Matrix Storage

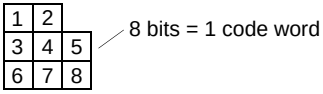


The Quiet Zone is a clear white space surrounding the Data Matrix, without clutter or text of any kind. The width of the quiet zone must be at least the size of one cell. The quiet zone should be at least 10% of the width or height of the symbol in order to achieve an optimum read rate.

Bit Versus Code Word

The ECC200 Data Matrix uses a byte-oriented (one Code Word) error detection and correction algorithm. The non-ECC200 uses a bit-oriented algorithm. Each ECC200 Data Matrix consists of multiple code words. Each code word contains 8 bits (also called elements or cells), as shown in Figure A–5.

FIGURE A–5. Shows 8 bits as 1 code word



The AIM Specification is designed for ECC200, which is *code word*-based. If any cell within the code word is incorrectly identified, the code word is subsequently affected by that bit and thus requires error correction. Since it is the code word that matters in the error correction algorithm, one single bit can cause the same amount of damage as the eight wrong bits in the same code word. For example, if one bit within the code word is in error the entire code word is in error. Likewise, if multiple bits within the same code word (e.g., 2-8 bits) are in error, this still counts as *one* code word in error.

The DMx Verifier+ is designed to cover both ECC200 and non-ECC200 Data Matrices. As a result, the number of wrong cells or bits (not code words) is displayed in the DMx Verifier+. The code word affected by displayed bits can also be displayed for the ECC200 Data Matrix.

Data Matrix Error Correction

Error correction provides safeguards and additional capabilities for handling poorly printed or damaged symbols. You select Error Correction Codes (ECC) when encoding the Data Matrix symbol. Data Matrix is the only symbology that offers both Reed-Solomon (ECC 200) and Convolutional error correction codes (ECC 000-140). Reed-Solomon is a byte-correcting scheme preferred for block damage recovery. Convolutional code is a bit correcting scheme preferred for random damage recovery. With the proper choice of Error Correction Code for a given environment, a high rate of decoding can be achieved.

In Convolutional code, as the ECC level increases, data redundancy is added to the Data Matrix symbol, as well as increased overhead (OVHD) in ECC 000-140. Additionally, as the ECC levels increase, the physical marked area increases proportionally. The redundant data is randomly placed (encoded) inside the data storage area to increase the symbol's ability to recover from damage.

In Reed-Solomon code, the OVHD varies and is based on the size of matrix. Refer to Table A–4, "ECC 200 Symbol Attributes," on page A-8 for more information.

The examples, as shown in Figure A–6, illustrate Data Matrices with different ECC levels and how ECC affects symbol density.

FIGURE A–6. Data Matrix Examples With Different ECC Levels

Refer to Table A–1 for a correlation between ECC levels and required overhead.

TABLE A–1. Correlation Between ECC Levels & Required Overhead

Selected ECC Levels	Required Overhead (%)
00	0
50	25
80	33
100	50
140	75
200	Various

Data Matrix Encodation Schemes

This section describes ECC 000-140 and ECC 200.

ECC 000-140

The data is encoded using one of six encodation schemes (format strings). The encodation scheme is fixed for the entire symbol. As a result, the selection of the most appropriate encodation scheme allows you to compress the symbol to its smallest form without wasting space on characters not used. Table A–2 lists the six encodation schemes and their outputs.

TABLE A–2. Encodation Schemes — Format Strings

Encodation Scheme	Format Outputs and Description	Bits per Data Character
Format 1	500 numeric characters (0-9) with spaces	3.5
Format 2	500 uppercase alphabetic characters with spaces and punctuation	4.8
Format 3	500 uppercase alphanumeric characters with spaces, commas, periods, slashes and minuses	5.25
Format 4	500 uppercase alphanumeric characters with spaces	5.5
Format 5	500 characters with full 7-bit ASCII keyboard	7
Format 6	500 characters with full 8-bit ISO for international languages	8

ECC 200

The data may be encoded using any combination of six encodation schemes listed in Table A–3.

TABLE A–3. Encodation Schemes — File Formats

Encodation Scheme	Characters	Bits per Data Character
ASCII	Double-digit numeric ASCII values 0-127 Extended ASCII values 128-255	4 8 16
C40	Primary upper-case alphanumeric	5.33
Text	Primary lower-case alphanumeric	5.33
X12	ANSI X12 EDI data set	5.33
EDIFACT	ASCII values 32-94	6
Base 256	All byte values 0-255	8

Table A–4 lists ECC symbol attributes.

TABLE A–4. ECC 200 Symbol Attributes

Symbol Size:[1]		Data Region:		Inter-leaved Blocks	Data Capacity:			Error Correction Overhead %	Max. Correctable Percentage %
Row	Col.	Size	No.		Num. Cap	Alphanum. Cap	Byte Cap		
10	10	8x8	1	1	6	3	1	62.5	25
12	12	10x10	1	1	10	6	3	58.3	25
14	14	12x12	1	1	16	10	6	55.6	28/39**
16	16	14x14	1	1	24	16	10	50.0	25/38
18	18	16x16	1	1	36	25	16	43.8	22/34
20	20	18x18	1	1	44	31	20	45.0	23/38
22	22	20x20	1	1	60	43	28	40.0	20/34
24	24	22x22	1	1	72	52	34	40.0	20/35
26	26	24x24	1	1	88	64	42	38.9	19/35
32	32	14x14	4	1	124	91	60	36.7	18/34
36	36	16x16	4	1	172	127	84	32.8	16/30
40	40	18x18	4	1	228	169	112	29.6	15/28
44	44	20x20	4	1	288	214	142	28.0	14/27
48	48	22x22	4	1	348	259	172	28.1	14/27
52	52	24x24	4	2	408	304	202	29.2	15/27
64	64	14x14	16	2	560	418	278	28.6	14/27
72	72	16x16	16	4	736	550	366	28.1	14/26
80	80	18x18	16	4	912	682	454	29.6	15/28
88	88	20x20	16	4	1152	862	574	28.0	14/27
96	96	22x22	16	4	1392	1042	694	28.1	14/27
104	104	24x24	16	6	1632	1222	814	29.2	15/28
120	120	18x18	36	6	2100	1573	1048	28.0	14/27
132	132	20x20	36	8	2608	1954	1302	27.6	14/26
144	144	22x22	36	8*	3116	2335	1556	28.5	14/27
				2*					
Rectangular Symbols:									

TABLE A–4. ECC 200 Symbol Attributes (continued)

8	18	6x16	1	1	10	6	3	58.3	25
8	32	6x14	2	1	20	13	8	52.4	24
12	26	10x24	1	1	32	22	14	46.7	23/37
12	36	10x16	2	1	44	31	20	45.0	23/38
16	36	14x16	2	1	64	46	30	42.9	21/38
16	48	14x22	2	1	98	72	47	36.4	18/32

Note 1: Symbol size does not include a quiet zone.

Note*: In the largest symbol (144x144), the first eight Reed-Solomon blocks are 218 code words long encoding 156 data code words. The last two blocks encode 217 code words (155 data code words). All the blocks have 62 error correction code words.

Note**:The maximum correctable percentage can range between 28% and 39%.

Data Matrix Specification Details

This section provides excerpts from the AIM International Technical Specification – International Symbology Specification -- Data Matrix (1996). Refer to the AIM Specification for complete information.

For new applications, ECC 200 is recommended. ECC 000-140 should only be used in closed applications where a single party controls both the production and reading of the symbols and is responsible for overall system performance.

The characteristics of the code consist of:

1. Encodable character set:
   a. Values 0-127 in accordance with ANSI X3.4, i.e., all 128 ASCII characters (equivalent to the US national version of ISO 646).
   b. Values 128-255 in accordance with ISO 8859-1; Latin Alphabet No. 1. These are referred to as extended ASCII.
2. Representation of data — A dark module is a binary 1 and a light module is a binary 0. In a reversed image (reverse polarity), a light module is a binary 1 and a dark module is a binary 0.
3. Symbol size in modules (not including the quiet zone):

ECC 000-140
9 by 9
to 49 by 49
Odd only

ECC 200
10 by 10
to 144 by 144
Even only

Note: Refer to Table A–4, “ECC 200 Symbol Attributes,” on page A-8 for more information.

4. Data characters per symbol (refers to maximum symbol size in ECC 200):

Alphanumeric data:	up to 2335 characters
8-bit byte data:	1556 characters
Numeric data:	3116 digits

5. Selectable error correction:

   ECC 000-140 — Four levels of convolutional error correction, plus the option to apply only error detection.
   ECC 200 — Reed-Solomon error correction.

6. Code type: Matrix

7. Orientation independence: Yes

Summary of Additional Features

The following summarizes additional Data Matrix features, including whether inherent to the Data Matrix, or optional:

- Reflectance reversal: (Inherent) Symbols are intended to be read when marked such that the image is either dark on light or light on dark.
- Extended Channel Interpretations: (ECC 200 only, optional). This mechanism enables characters from other character sets (e.g.: Arabic, Cyrillic, Greek, Hebrew) and other data interpretations or industry-specific requirements to be represented.

- Rectangular symbols: (ECC 200 only, optional). Six symbol formats are specified in a rectangular form.
- Structured append: (ECC 200 only, optional). This allows files of data to be represented in up to 16 Data Matrix symbols. The original data can be correctly reconstructed regardless of the order in which the symbols are scanned.

Symbol Structure

Each Data Matrix symbol consists of data regions, which contain nominally square modules, set out in a regular array. In larger ECC 200 symbols, data regions are separated by alignment patterns. The data region is surrounded by a finder pattern and, as a result, is surrounded on all four sides by a quiet zone border.

The Finder Pattern is a perimeter to the data region and is one module wide. Two adjacent sides (left and lower sides) forming the L-shaped boundary are solid dark lines. These sides primarily determine physical size, orientation and symbol distortion. The two opposite sides are made up of alternating dark and light modules. These are used primarily to define the cell structure of the symbol, but can also assist in determining physical size and distortion.

Regarding Symbol Sizes and Capacities, the ECC 000-140 symbols consist of an odd number of rows and columns. Symbols are square with sizes from 9x9 to 49x49 (modules) not including quiet zones. These symbols can be recognized by the upper right corner module being dark. For an image of reversed polarity, it would be light. Complete attributes for ECC 000-140 symbols are provided in the *AIM International Technical Specification, International Symbology Specification — Data Matrix (1996)*.

ECC 200 symbols consist of an even number of rows and columns. Some symbols may be square with sizes from 10x10 to 144x144 not including the quiet zone. Other symbols may be rectangular with sizes from 8x8 to 16x48 not including quiet zone. All ECC 200 symbols can be recognized by the upper right corner being light dark. For an image of reversed polarity, it will be dark. Complete attributes of ECC 200 symbols are provided in the *AIM International Technical Specification, International Symbology Specification — Data Matrix (1996)*.

Appendix A Data Matrix Symbology

B

APPENDIX B

Creating A Good Image

This appendix provides guidance on creating a good image.

Introduction

To successfully use your DMx Verifier+ system, you must know how to obtain a clear, precise image of the part and features you want to inspect. Factors that contribute to obtaining a good image include:

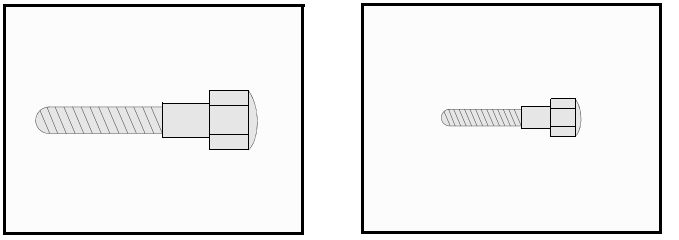
- Determining the Field of View
- Selecting a lens
- Illuminating the part
- Advanced lighting
- Aperture
- Depth of Field
- Lighting tips

Determining the Field Of View

Determining the best FOV, that is the area viewed by the camera is your first consideration before setting up a camera for your application. The object of interest should appear as large as possible in the FOV. The field of view should clearly show the level of detail you want to see while ensuring that the part to be inspected is always seen by the camera.

The general rule is to fill the FOV with the part you are inspecting, leaving enough space around the part to compensate for part positioning. This provides a superior image of the part and regions of interest for the system to see. In Figure B–1, the image on the left provides more detail, and thus a more desirable image than the one on the right.

FIGURE B–1. Fields of View



Selecting Lens

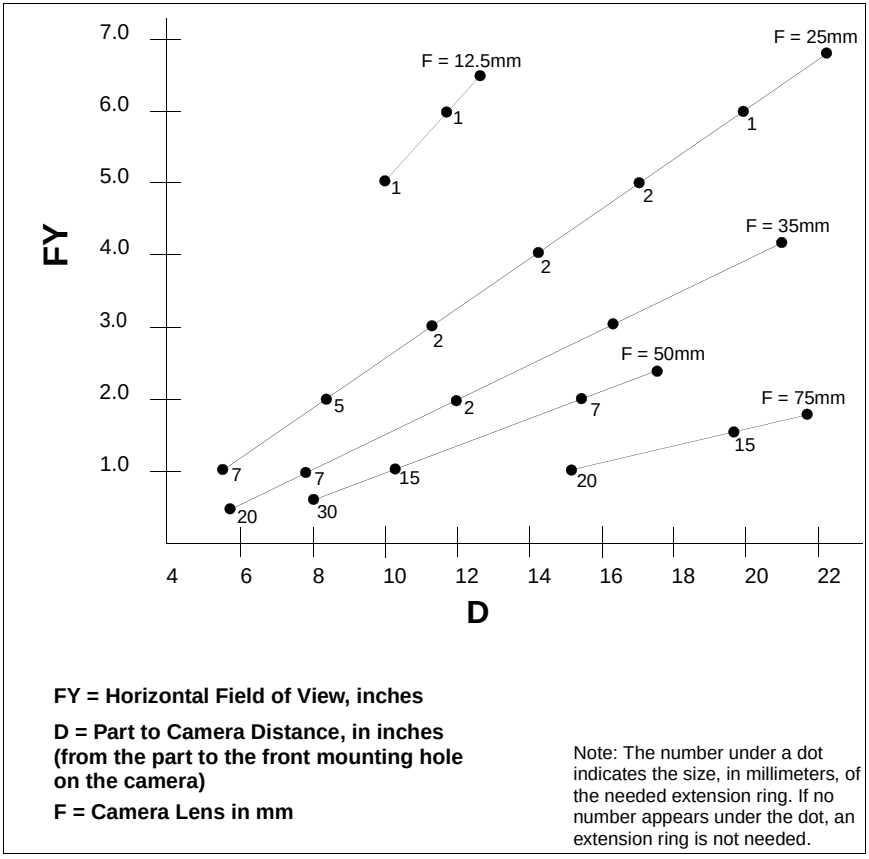
Selecting a lens is one of the most critical factors for obtaining a good image.

Lenses used for 35mm SLR cameras are preferable for use with the CM4000 camera than standard C-mount lenses when performing accurate measurements. Lenses for 35mm SLR cameras are more optically accurate and therefore, more expensive. However, they are larger than C-mount camera lenses and may cause a problem in mounting a camera in a particular enclosure.

To use an 35mm SLR camera lens with your CM4000 camera, you need to use a C-mount to F-mount adapter.

Use the Lens Selection Chart, as shown in Figure B–2 to determine the lens size. As a general guideline, lenses that have a longer focal length make the object appear closer (larger) and show less of the background. For example, a 50mm lens has a longer focal length than a 25mm lens.

FIGURE B–2. Lens Selection Chart

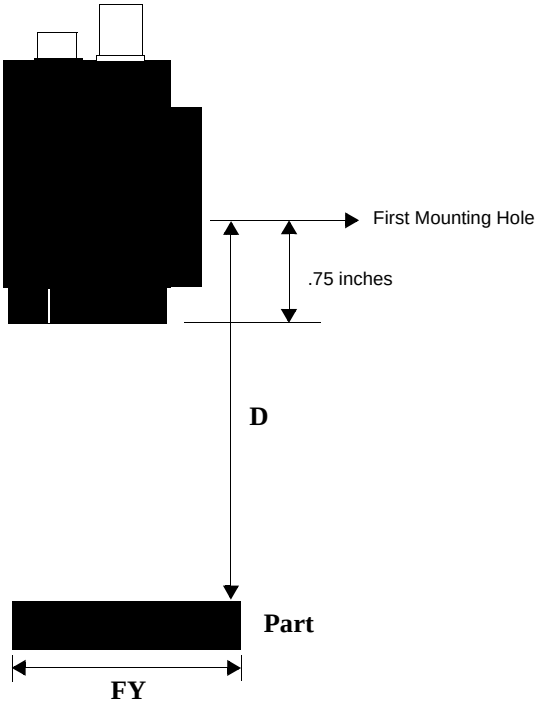


Using the Lens Selection Chart

The Lens Selection Chart helps you choose the appropriate lens using *approximate* dimensions. For very precise measurements, you may need to use a precision, low-distortion lens. Contact Application Engineering ((603) 598-8400) for a recommendation that is specific to your measurement task.

First, determine the required *horizontal field of view* (FY). Use a dimension of *.75 inches* from the front of the camera to the *first mounting hole*, as shown in Figure B–3. Next, measure the distance from the part to the *first mounting hole* on the camera (D).

FIGURE B–3. Determining Lens Selection



Select a lens using the Lens Selection Chart. The chart also indicates if you need an extension ring. An extension ring decreases the distance from the lens to the part and causes a smaller FOV.

Illuminating the Part

Proper illumination of the part is a critical factor influencing the effectiveness of the inspection operation. There is no absolute procedure to follow however, the following basic lighting concepts, combined with some experimentation, will help you create good lighting.

Note: Never rely solely on ambient lighting. Always use task lighting designed for your application.

Lighting Considerations

When it comes to lighting a part for vision analysis, the following features should be considered when selecting a lighting scheme.

- Surface Characteristics — Surface characteristics, as they relate to light, is a critical element when selecting the correct lighting type. The type of surfaces listed below and their color, must be considered before purchasing your illumination style.
  - Textured
  - Reflective
  - Diffuse
  - Absorptive
  - Color
- Geometry — The geometry may determine the direction of the illumination. Will the complete item require illumination?
- Size — The size of the part will determine the size of the light.
- Region of Interest (ROI) — How will the ROI compare to the rest of the part.

Types of Lighting

With the advent of advances in lighting, selecting an appropriate illumination type can be confusing. Basic and Advanced Illuminations types will be discussed and their basic influences explained. Diffused, Point-source lighting and polarizers also influence lighting. Also, the placement of the light source will affect you decision on lighting types. For difficult lighting applications, contacting a illumination authority would be suggested.

- Basic Illumination
  - Fluorescent
  - Incandescent
  - Laser
  - LED (Light Emitting Diode)

  - Strobe
- Accessories
  - Fiber Optics
  - Diffusers
  - Beam Splitters
- Advanced Illumination
  - DOAL™
  - CDI™
  - SCDI™

Fluorescent Versus Incandescent Lighting

Preference for using fluorescent lighting, as presented in Table B–1 or incandescent lighting, as presented in Table B–2 depends on several factors. However, the general rule should be to use fluorescent lighting whenever possible.

TABLE B–1. Fluorescent Lighting

Positive Features	Negative Features
Diffuse	Flickering light
Usually easy to mount	Lack of intensity
Long life	Light output decays with age
Inexpensive	
Creates little heat	

Note: Fluorescent lighting tends to be diffuse and not concentrated on a part. If the part is being magnified by a lens or if the lens aperture is small (stopped down), you may find the light level insufficient.

TABLE B–2. Incandescent Lighting

Positive Features	Negative Features
High intensity	Shorter life than fluorescent
Inexpensive if you use home light bulbs	Expensive if fiber-optic lights are used
No flicker	Source of infrared light[a]
Light output constant over life of bulb	Creates excessive of heat[b]

a. It is usually necessary to place an infrared filter in front of the camera lens when using an incandescent light source. The camera has a high sensitivity to infrared light that reduces the contrast and resolution found in an image.

b. If you use fiber optics, the part being illuminated is not heated. If you use conventional bulbs, the part being inspected may get hot.

Lasers

A laser is an excellent source of light when you need to:

- Illuminate a small area
- Create a structured lighting effect
- Create a three-dimensional simulation, for example, measure depth

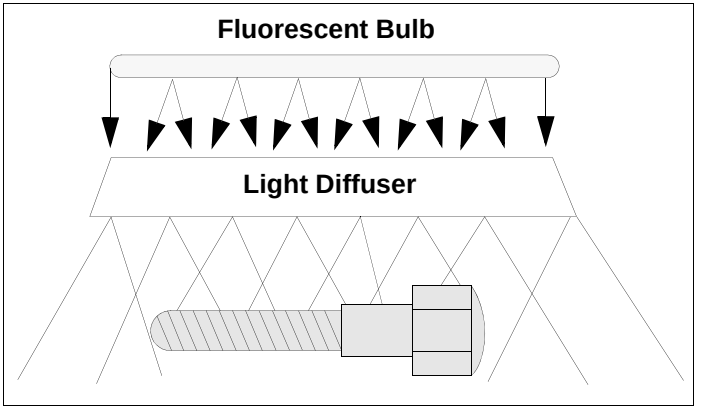
Strobe Lights

Use a strobe light when you need to freeze the image of a moving part. Strobes provide a very short-duration, high-intensity light. In most cases you should use fiber optics to project the light to the required area.

Diffuse Versus Point-Source Lighting

Diffuse light, as shown in Figure B–4, casts no shadows, minimizes glare, and appears to originate from no particular direction. Most inspection applications work best with diffuse light.

FIGURE B–4. Diffuse Light

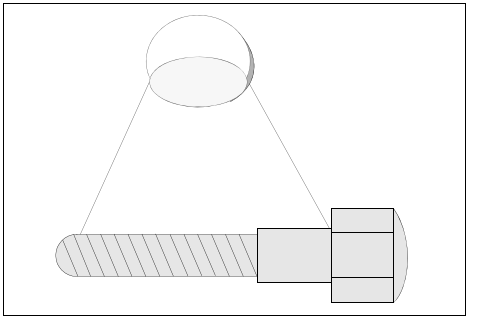


Good sources of diffuse light include:

- Fluorescent ring lights
- Long fluorescent bulbs with or without diffusers

Point-source lighting, as shown in Figure B–5, casts very strong shadows. This is desired when the presence or absence of a shadow can reveal information about the presence of depth. Points sources are effective for revealing surface defects.

FIGURE B–5. Point-Source Light



Good point-source lights include:

- Incandescent spot lights
- Fiber-optic sources

- Unfrosted incandescent light bulbs
- Strobe lights

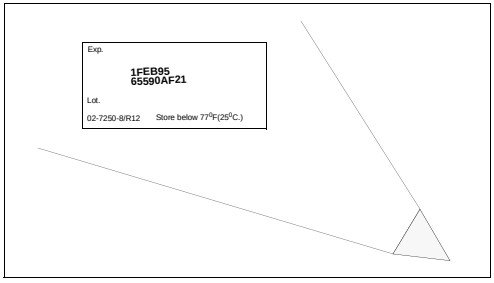
Placement of Light Sources

There are three basic light source positions: front, side, and back.

Front Lighting

Front lighting is good for the inspection of flat, two-dimensional surface features, such as a label, as shown in Figure B–6.

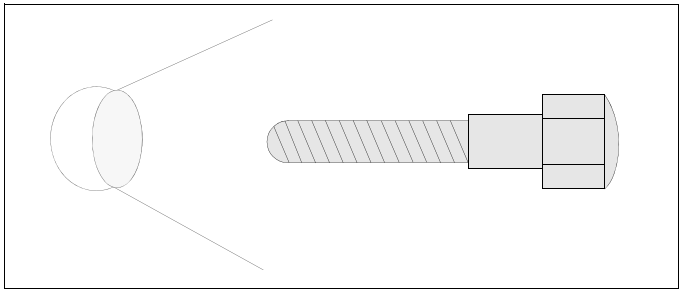
FIGURE B–6. Front Lighting



Side Lighting (Dark Field)

Side lighting helps to highlight three-dimensional features and surface imperfections, and reveals subtle details as shown in Figure B–7.

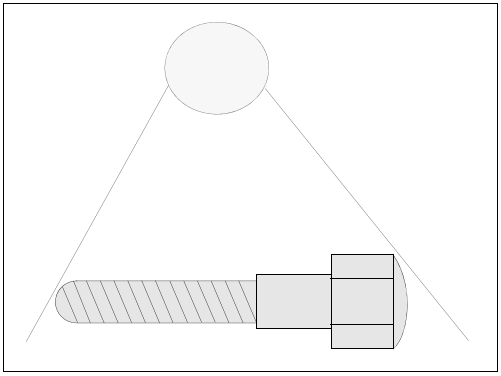
FIGURE B–7. Side Lighting



Back Lighting

Back lighting helps in the inspection of silhouettes, for example, the outer edges of a part. It enhances the contrast between the part and the background. Think of contrast as the gray-scale difference between two areas. Back lighting is helpful in the inspection of holes, cutouts, and outline dimensions as shown in Figure B–8.

FIGURE B–8. Back Lighting

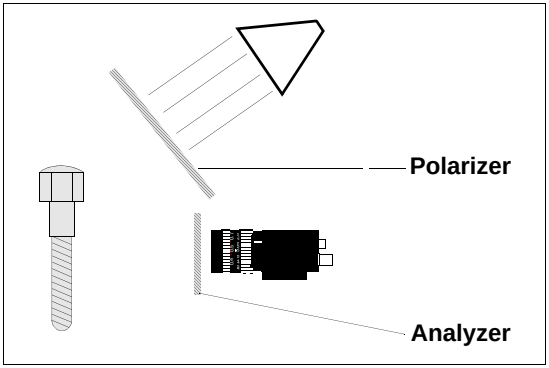


Polarized Light

Polarized light helps reduce glare on an object when the glare interferes with a visual inspection, such as when attempting to read a label.

To polarize light, place polarizing material over the light source as shown in Figure B–9. Another piece of polarizing material (an analyzer) is placed in front of the camera lens and rotated until the glare, or mirror-like reflection, is minimized.

FIGURE B–9. Polarized Light



For some applications glare may be helpful and you would not want to eliminate it. For example, a hole in an object may be more easily seen on a surface that has glare. In all cases, you will want to adjust the rotation of the polarizing material to maximize the image contrast of the features you wish to inspect.

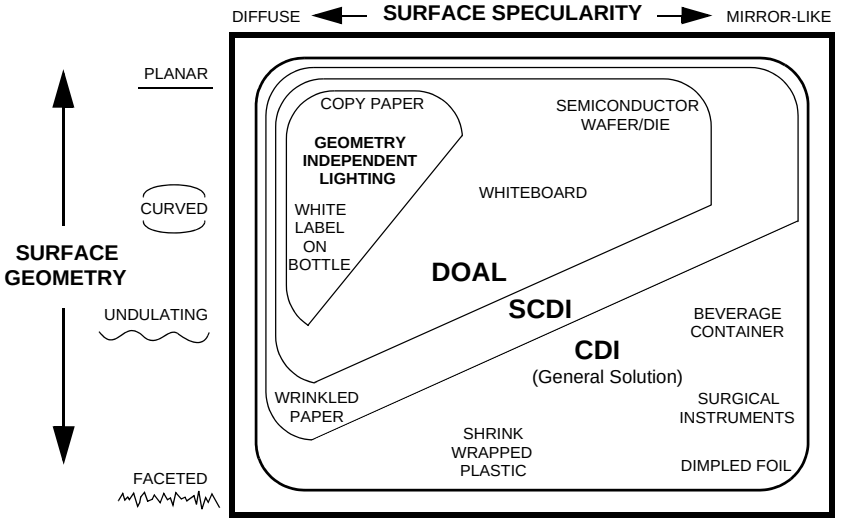
Advanced Lighting

Northeast Robotics, Inc. is a recognized leading provider of lighting systems designed specifically for machine vision applications. These products allow machine vision systems to perform reliably in difficult imaging applications involving highly reflective or uneven surfaces. NER is the inventor of:

- DOAL™ — Diffused On-Axis Lighting. Refer to “DOAL” on page B-12
- CDI™ — Cloudy Day® Illumination. Refer to “CDI” on page B-13
- SCDI™ — Square Continuous Diffuse Illumination. Refer to “SCDI” on page B-14

Figure B–10 illustrates these lighting types and their applications.

FIGURE B–10. Lighting Solutions for Image Absorptive Features



To address your lighting issues, contact NER at:

Microscan, Inc.
486 Amherst St.
Nashua, NH 03063
Tel. 603-598-8400
Fax 603-577-5976

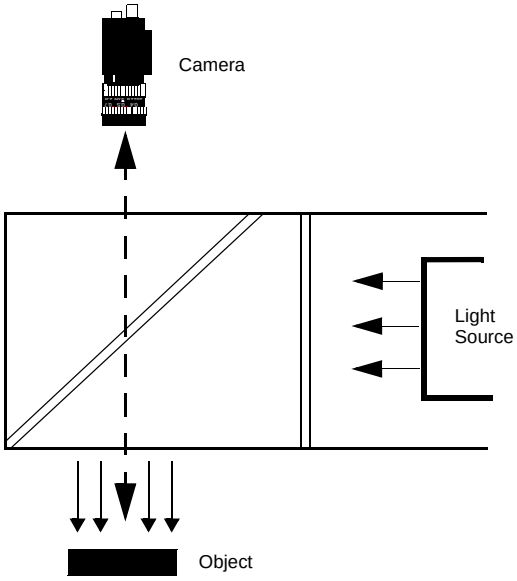
DOAL

Ideal for flat specular surfaces. Diffused On-Axis Lighting provides more than 300% greater angular coverage of the lighting envelope than a similarly sized fluorescent ring light. DOAL can be used at a distance to provide uniform wide-angle colluminated illumination for imaging highly specular flat surfaces. Refer to Figure B–11.

- Superior uniformity
- Significantly enhances image quality
- Improves the accuracy and repeatability of machine vision performance on specular surfaces

- Illumination sources include LED, fiber-optic and micro-fluorescent sources
- Flexible light-field / dark-field illumination characteristics depending on distance to target

FIGURE B–11. Diffused On-Axis Lighting

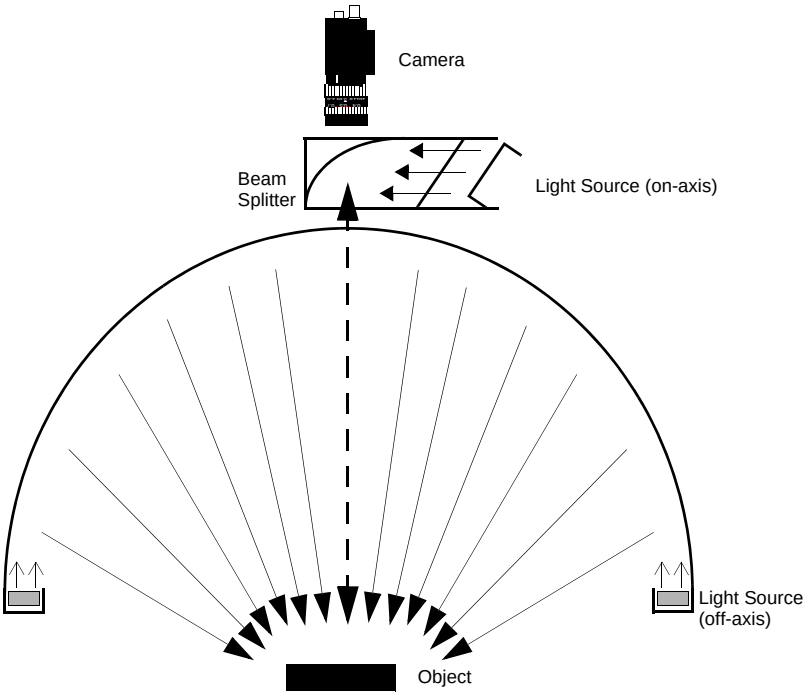


CDI

Ideal for very *uneven specular surfaces*. Continuous Diffuse Illumination (CDI), also known as Cloudy Day Illumination, provides a hemisphere of diffuse, uniform illumination. The complete lighting envelope has even lighting from all directions. The use of a curved beam splitter completes the horizon-to-horizon illumination. On-axis and off-axis lighting is controlled separately to ensure that uniformity remains in balance. Refer to Figure B–12.

- Outstanding uniformity up to ±10% maximum deviation within the lighting envelope
- Illumination sources include LED, fiber-optic and white microfluorescent sources

FIGURE B–12. Continuous Diffuse Illumination

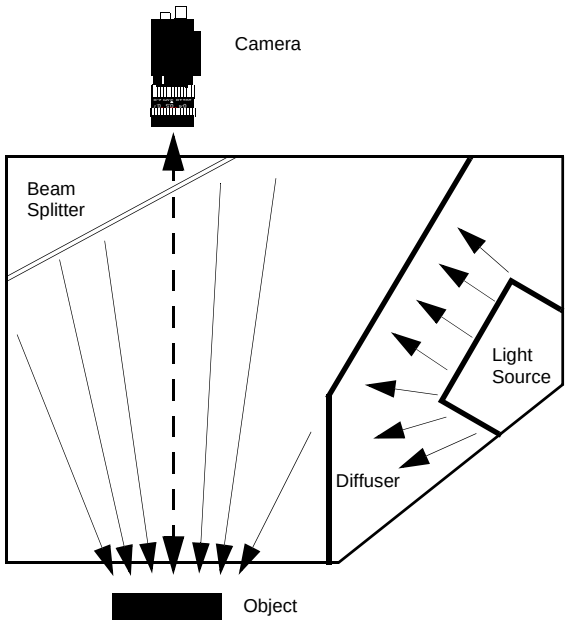


SCDI

Ideal for uneven specular surfaces. Square Continuous Diffuse Illumination (SCDI) increases the uniformity of on-axis illumination by ensuring direct light from the diffuser is equally intense as light coming from the beam splitter and the lighting cavity. Increasing the diffuser width and elongating the chamber ensures any light directed to the object is uniform. Refer to Figure B–13.

- Excellent uniformity ±20% across the lighting envelope at close range
- Extraordinary diffuse illumination
- Illumination source include LED and microfluorescent sources

FIGURE B–13. Square Continuous Diffuse Illumination



Aperture

The aperture is the adjustable opening in a lens that varies the amount of light reaching a target.

The f-stop indicates the size of the opening. The larger the number, the smaller the opening.

As you go from a smaller number to the next larger one, e.g., 11 to 16, the amount of light reaching the target in the camera is reduced by one-half.

The best image is obtained at the higher f-stops settings however, the aperture is smaller and less light enters the lens. You will have to experiment with the aperture setting to obtain the best image for your application and lighting.

Depth Of Field

Depth of field is the size of the front-to-back distance that is in focus. The aperture opening is the most important influence in determining the depth of field:

- When using a *small* aperture (high f-stop number), much of the area, both in the foreground and background of the object, will be in focus. More light is required when the aperture is small. This provides greater depth of field and reduces the effects of ambient light.
- When using a *large* aperture, the object is in focus, but the areas in the foreground and background of the object are out of focus.
- Many lenses come with an information sheet detailing depth of field at various F-stop settings and working distances.

Lighting Tips

- To light a round part, try using a round light source that provides even lighting on the inspected parts, such as CDI (Cloudy Day Illumination).
- Experiment with different light positions and sources until you find the best illumination for your part.
- If you place a point-source light close to the part, you will likely produce a harsh glare with black shadows.
- To *fill in* (minimize) shadows, use lighting sources with a diffuser such as, CDI.
- Your lighting should be much brighter than the room in which the inspection is taking place.
- It is often best to light the environment, *not* the part.
- An enclosure around the inspection station will minimize the impact of ambient light as well as protect lights and cameras.

Lighting provides a clear image that is not too bright or too dark and enables the Vision Processor to identify the desired features and characteristics. Refer to Table B–3 for additional lighting information.

TABLE B–3. Additional Lighting Information

Lighting Type	Hardware Required	Representative Applications
EVEN - FRONT (DIFFUSED)		
Band	Fluorescent Tube - Straight or Circular	Simplest general purpose lighting. Always try this first.
Zone	Diffuser Plate or Reflecting Panel DOAL CDI SCDI	Detect broken microscope slides.
POINT - FRONT		
Point Source	Fiberlight or Incandescent DOAL CDI SCDI	Use where high intensity lighting is required on small area. Also for shadow fill-in and general lighting touch-up.
Multiple Point Sources	Multiple Fiberlights or Incandescents DOAL CDI SCDI	Symmerical high-intensity illumination of microscopic fields-of-view such as electronic components.
EVEN - BACK		
Backlighting	Light Box or Uniform Surface	Dimensioning highly reflective parts, inspecting contours of parts with highly variable surfaces.
STRUCTURED		
On-Axis	DOAL Beam - Splitter	See flat dark reflective surfaces. Front-light deep holes.
Light Line	Laser with Cylinder Lens	Relative height measurements of surfaces. Non-contact gaging.
SPECIAL EFFECTS		
Polarizing	Polarizing on Light Sources and Lens	Minimize glare and variable glints on top-lit reflective surfaces
Color	Interference and Gelatin Filters	Discriminate copper and steel. Make variable colored parts appear more similar to camera.
Strobe	Strobe Source and Synch Box	Use wherever the part moves more than one pixel in 17 milliseconds.

Appendix B Creating A Good Image

Index

Numerics
8-bit Binary Code A-4

A
Additional Features A-10
AIAG A-1
AIM A-1, A-9
  standard 2-1
  verification 2-3
Angle of Distortion 2-7, 2-15, 3-5
ANSI A-7
Aperture B-15
ASCII A-7
Auto Check 3-1, 3-14
Automatic Identification Manufacturers International, Inc. A-1
Automotive Industry Action Group A-1
Axial
  nonuniformity 2-4, 2-8, 2-13, 2-17
  uniformity 3-5

B
Back Lighting B-10
Barcode A-2
Binary Code A-4
Bit Versus Code Word A-4
Border Match 2-12, 3-4
Broken Border A-4

C
Camera
  cables 1-6, 1-8
  clamping lens 1-9
  connecting cable 1-6
  connection 1-6
  f-stop B-15
  grounding 1-7
  mount checklist 1-7
  mounting 1-7, 1-8
  positioning 1-9
CDI B-13
Cell
  modulation 2-12, 3-4
Center Offset 2-11, 2-18, 3-4
Certifications A-1
Checklist
  camera mount 1-7
Clamping Camera Lens 1-9
CM4000 1-7
C-mount Adapter
  needed with 35mm SLR lens B-2
Code Word Versus Bit A-4
Components
  data matrix A-3
Configuration
  base 1-2
Considerations
  parameter 2-16
Continuous Diffuse Illumination B-13
Contrast 3-4

D
Data
  regions A-11
  storage area A-4
Data Matrix
  8-bit binary code A-4

additional features A-10
components A-3
error correction A-5
examples A-2
what it is A-1
Depth of Field 1-9, B-16
Diffuse Lighting B-7
Diffused On-Axis Lighting B-12
DMx Verifier+
scanning options 1-3
starting 1-10
what it is 2-1
DOAL B-12
Dongle 1-4
Dot
center offset 2-6
size 2-6
DPM
parameters 2-18
standard 2-2

E

ECC
000-140 A-5, A-6, A-11
200 A-5, A-7, A-10, A-11
level A-6
EIA A-1
Electronics Industries Association A-1
Encodation Schemes
file formats A-7
format strings A-6
Environment 1-5
Error Correction 2-17
codes A-5
Examples
iaqg 2-19
verification 2-16
Extended Channel Interpretations A-10
Extension Ring B-4

F

Field of View 1-8, B-2, B-4
ensuring best 1-8
File
formats A-7
menu 4-2
Finder Pattern A-11
Fixed Pattern Damage 2-10
Fluorescent Lighting B-6
F-mount adapter
needed with 35mm SLR lens B-2
Focal Length B-2
Focus 1-9
Foreshortening 1-9
Format Strings A-7
Front Lighting B-9
F-stop 1-9, B-15

G

General Parameters 2-16
Geometry B-5
Grid Nonuniformity 2-9
Ground Loop 1-7
Grounding the camera 1-7
Guidelines
verification 2-16

H

Help Menu 4-27
Horizontal
field of view B-3

I

IAQG
standard 2-1
verification 2-5
IAQG/AS9132 Parameters 2-17
Illumination B-4
Image
obtaining a good B-1
Incandescent Lighting B-6
Inspection Options 1-3
Installing
internal camera power cable 1-6
Internal
cabling 1-6
camera power cable
installing 1-6
ISO 15415
parameters 2-18
standard 2-2
verification 2-7

L
Laser Lighting B-7
Lens
  35mm B-2
  aperture B-15
  chart B-2, B-3
  distance B-4
  extension ring B-4
  focal length B-2
  focus 1-9
  f-stop B-15
  selection B-2
  selection chart B-2
Lighting
  back B-10
  CDI B-13
  continuous diffuse illumination B-13
  diffused on-axis B-12
  DOAL B-12
  factors B-4
  fluorescent B-6
  for flat specular surfaces B-12
  for very uneven specular surfaces B-13
  front B-9
  incandescent B-6
  laser B-7
  placement B-9
  point-source B-7
  polarized B-10
  SCDI B-14
  side B-9
  square continuous diffuse illumination B-14
  strobe B-7
  tips B-16
  uneven specular surfaces B-14
Location Considerations 1-4

M
Menus
  file 4-2
  help 4-27
  pre process 4-18
  set 4-5
  tools 4-19
  view 4-15
Modulation 2-10
Module Fill 2-7
MXi
  interface 3-1

N
Nominal Cell Size 2-3, 3-4

O
Offset
  center 2-18
  size 2-18
Ovality 2-7
Overall
  grade 2-7, 2-10, 2-15, 3-5
  symbol grade 2-5
OVHD A-5

P
Parameter Considerations 2-16
Point-Source Lighting B-7
Polarized Light B-10
Pre Process Menu 4-18
Print Growth 2-4, 2-10, 2-14, 2-17, 3-5
Printing
  data to a file 3-17
  image only 3-17
  image with verification results 3-17

Q
Quiet Zone A-4

R
Rectangular Symbols A-11
Reference Decode 2-8
Reflectance
  reversal A-10
Region of Interest B-5
ROI B-5

S
Sample
  data matrix with errors 3-6
  overprinted data matrix 3-11
  perfect data matrix image 3-3
  underprinted data matrix 3-13
Scan Grade 2-10
Scanning Options 1-3
SCDI B-14

SEMI Standard T2 A-1
Set Menu 4-5
Setup
  system 2-16
Side Lighting B-9
Size B-5
  offset 2-11, 2-18, 3-4
Software Protection Key 1-4
Solid Border A-4
Square Continuous Diffuse Illumination B-14
Standards
  aim 2-1
  iaqg 2-1
  iso 15415 2-2
Starting Verifier 1-10
Status
  verification 2-15
Strain Relief 1-8
Strobe B-7
  lighting B-7
Structured Append A-11
Surface Characteristics B-5
Symbol
  attributes A-7
  contrast 2-3, 2-7, 2-8, 2-13, 2-16
  density A-6
  structure A-11
Symbology A-1
System
  configuration 1-2
  setup 2-16

T
Tips
  lighting B-16
Tools
  menu 4-19
  recommended 1-5

U
Unused Error Correction 2-4, 2-9, 2-14, 3-5

V
Verification
  aim 2-3
  examples 2-16
  guidelines 2-16
  iaqc 2-5
  iso 15415 2-7
  status 2-15
View Menu 4-15

X
X Nominal Cell Size 2-3

Y
Y Nominal Cell Size 2-3